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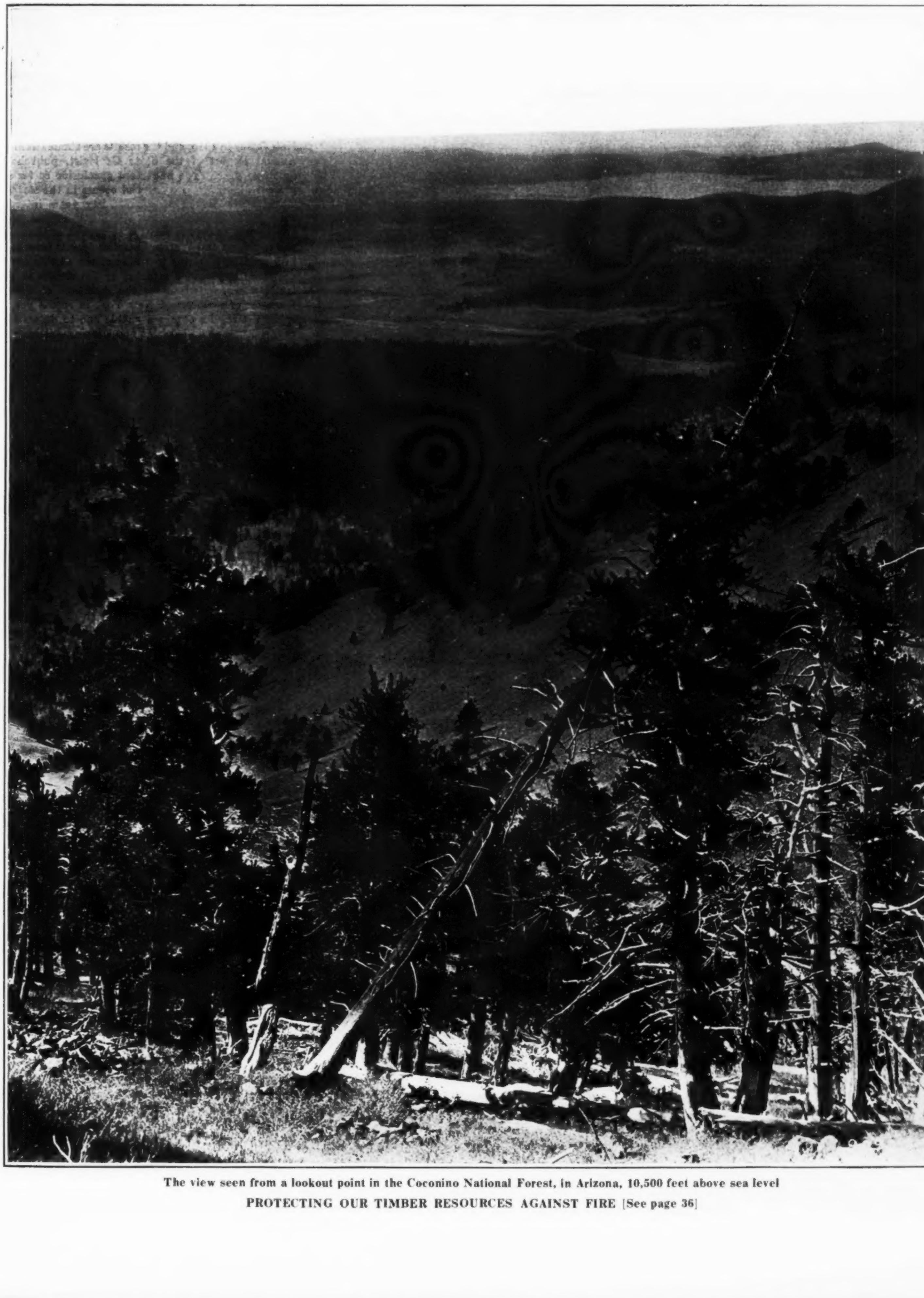


The view seen from a lookout point in the Coconino National Forest, in Arizona, 10,500 feet above sea level

PROTECTING OUR TIMBER RESOURCES AGAINST FIRE [See page 36]

Is The Atlantic Coast Sinking?*

A Review of the Latest Contributions to an Old Problem

By Douglas W. Johnson

MORE than half a century ago Professor George H. Cook, then state geologist of New Jersey, presented striking and apparently convincing evidence that the Atlantic coast of North America was gradually subsiding at the rate of two feet per century. Farm lands under cultivation fifty years before were, at the time of his investigation, covered with salt marsh grasses; old corduroy roads were encountered several feet below the surfaces of salt marshes at many points along the shore; and, within the memory of men then living, the ocean waters had risen so high upon the wheels of tidal mills that their operation had become difficult or impossible. The scientific manner in which Professor Cook presented his arguments gained for him not only the respect of geologists in all parts of the world but a very general acceptance of his interesting conclusions.

Independent investigation of the shores of England, southern Scandinavia, the Netherlands, and France convinced many geologists in those countries that the Atlantic coast of Europe was suffering a subsidence similar to that of the North American coast. On both sides of the North Atlantic, therefore, there has long existed a conviction that the land is slowly but surely sinking beneath the ocean waters. In America in particular it has been accepted as a well-established fact that a subsidence of from one to two feet per century is still in progress.

On various occasions the writer has discussed the supposed evidences of recent coastal subsidence along the Atlantic coast of the United States and southeastern Canada, and has presented reasons for believing that the so-called proofs of land sinking within historic times were open to alternative explanations, whereas the physiographic evidence could only be explained by postulating long-continued coastal stability. Studies on the eastern and southeastern coasts of England, the coast of Holland, and the coast of southern Sweden indicated that in like manner the supposed proofs of recent subsidence in those regions were open to criticism, while the physiography of the English and Swedish coasts furnished convincing evidence that the relative level of land and sea had not changed appreciably for many hundreds of years. A careful study of numerous reports by French observers detailing the evidence of a recent progressive subsidence of the western coast of France led to the conclusion that this evidence was not of such a character as to establish the subsidence theory; but the writer made no personal examination of this coast.

The apparent evidences of subsidence are so striking, and the conclusions in favor of recent coastal stability, in the localities in question, are so radically opposed to the long-held opinions of most geologists and geographers, that it will be profitable to review briefly some of the latest contributions to this interesting problem. We may mention first some foreign studies and then return to investigations of our own coast.

Professor Jules Welsch of the University of Poitiers has recently applied to the study of the western coast of France the same methods of interpretation outlined in the writer's "Fixité de la côte Atlantique de l'Amérique du Nord"[1] and has published his conclusions in a paper entitled "Fixité de la côte du Centre-Ouest de la France."[2] This clearly written and well-illustrated report analyzes at length the supposed proofs of recent subsidence upon which earlier investigators have placed reliance, criticizes other evidence which led certain students to infer a recent elevation of the land, and finally presents physiographic evidence of long-continued coastal stability. His conclusion is expressed in the words, "There is no proof of a submergence or an emergence of the coast since the Neolithic epoch, that is to say, during the last few thousand years."

In a paper on "Den Formodede Littorina-Saenking in Norge"[3] Professor Hans Reusch discusses supposed proofs of a late post-glacial subsidence of Norway, particularly of the southern part of the coast. The evidence is largely in the form of submerged peat deposits, such as have frequently been cited by American students as indicating recent subsidence of our own coast. Professor Reusch shows that in each case the field relations are easily susceptible of an alternative explanation.

The Report of Progress of the Ordnance Survey of Great Britain, detailing operations up to March 31, 1916, contains results of precise leveling which are pertinent to the present discussion. I quote the following from the section on geodesy: "In the year 1837-38 a line of accurate leveling was executed by Mr. Bunt, in order to compare the mean sea-level of the Bristol Channel with that of the English Channel, and also to enable subsequent leveling to determine whether there had been any vertical movements of the land surface. . . . In the year under review, 78 years after the original operation, the line was very carefully releveled. . . . The difference between the two results for the length of 58.87 miles between Perry Farm and Axmouth is 1.12 inches. . . . The probable error of the new geodetic leveling from Perry Farm to Axmouth, as calculated from the discrepancies between fore and back leveling, is 0.17 inch. The probable error of Doctor Whewell's leveling of the same line, calculated in the same way, works out at 1.88 inches. . . . The chief result of the comparison is that there is no indication that there has been any change in the relative levels of the coast lines of the Bristol Channel and English Channel during the 78 years that have elapsed since Doctor Whewell's leveling was carried out."

In the Summary Report of the Geological Survey of Canada for the year 1914, published in 1916, there is a synopsis of the results secured by Professor J. W. Goldthwait in his physiographic work in Nova Scotia. From this it appears that Professor Goldthwait examined the old fortress at Louisburg, the position of which is so often asserted to prove a recent sinking of the land. The present writer had previously secured a report upon this locality through an assistant, Dr. Donald Barton, who was unable to find any evidence of a change of level in the vicinity of the fort. Professor Goldthwait reaches the conclusion that "there has been no sinking nor rising of the coast at this place during the last two centuries."

Dr. D. S. McIntosh, professor of geology in Dalhousie University, Halifax, has just published an interesting article entitled "A Study of the Cow Bay Beaches."[4] A number of drumlins near Halifax have been eroded by the sea, and with portions of the erosion products the waves have constructed a series of beach ridges. Examination of the rings of growth of stumps on the oldest ridge fixes its minimum age at about 150 years. Inasmuch as the crest of the oldest beach ridge has about the same altitude as that of the modern ridge, the author concludes that "these beaches are the effect of waves upon a stationary coast—one which has remained so for at least a hundred and fifty years."

A paper by Dr. J. W. Spencer on "Postglacial Earth-Movements about Lake Ontario and the Saint Lawrence River"[5] contains a section on the "present stability of the lake region," in which occurs a table of the mean differences of level between two permanent bench-marks at Port Colborne and Cleveland, 160 miles apart, as deduced from the daily records of lake level for a period of 57 years. Such a table is of interest because of the possibility, or even probability, that any subsidence or elevation of the land would be accompanied by a warping which would be revealed by a change in the relative levels of two points so far apart. No such change is apparent. Doctor Spencer concludes: "From a full study it is apparent that there has been no change of level in 57 years. . . . These results disprove my original suggestion (1894) that the Niagara discharge would be turned into the Mississippi in the not distant future. This idea was expanded into a monograph on earth-movements by Dr. G. K. Gilbert, who used the fluctuations of the lakes; but in so doing he took the levels of a few isolated days, irregularly selected. The erroneous results derived therefrom have been widely quoted, but the table given above contains the proof of the present stability of the lake region."

In connection with his study of the New Jersey coast, the present writer desired to ascertain whether there had been any warping or tilting of the state, such as might be expected to accompany the rapid subsidence generally believed to be in progress all along the New Jersey shores. He accordingly suggested to the state geologist the desirability of re-surveying certain lines of precise level in the southern part of the state, where the supposed evidence of subsidence was most striking, in order to determine whether the relative elevations of Atlantic City, Vineland, and Cape May Court House, three points of a triangle 30 miles on a side, had undergone any change since the important surveys of 1886. The leveling was done in 1911, and the results published the following year.[6] In the accompanying table the essential facts are made clear:

Place	Elevations in feet above sea-level 1886	1911	Difference
Cape May Court House.....	19.498	(19.498)	0.0
Vineland..................	108.100	108.082	—0.018
Atlantic Cty..............	8.954	8.931	—0.023

The agreement between the levels of 1886 and those of 1911 is extremely close and is well within the limits of the probable error of the observations. It is clear, therefore, that there has been no warping or tilting in the southern New Jersey region during the last quarter of a century.

Similar lines of level were run in the northern part of New Jersey in 1915, and the results are summarized in the Annual Report of the State Geologist, published the following year. The important conclusion so far as the present discussion is concerned occurs in the statement: "During the period of about thirty years intervening between the several series of levels, there has been no appreciable change in relative elevations at the seashore and in Sussex and Warren Counties (points from forty to fifty miles apart), due to tilting of the earth's crust."

Special importance attaches to the results of precise leveling prosecuted under the direction of the Chief Engineer of the City of New York in recent years, because the results obtained enable one to determine not only whether there has been any warping or tilting of the land in the vicinity of New York, but also, with equal certainty, whether or not the land mass as a whole has subsided. The data summarized below are taken from the report on "Precise Leveling in New York City," by Frederick W. Koop, published in 1915.

In 1887 a bench-mark on a monument at Perth Amboy was found to be 18.5763 meters above mean sea-level at Sandy Hook, and in that same year a bench-mark on a sea wall at Willets Point, 33 miles distant to the northeast, was determined as 4.3083 meters above the same datum plane. In 1911 Mr. Koop connected these points by a line of precise levels which showed that the relative positions of the two bench-marks had changed by an apparent amount of but 1.2 millimeters, or .004 feet. The slight apparent difference is less than the probable error of the earlier survey and proves that on a line 33 miles long no warping or tilting has occurred in the last quarter of a century.

Absolute elevation or subsidence of the land would be detected by comparing the absolute elevations of certain bench-marks in 1887 with the absolute elevations of those same bench-marks in 1911. It is not possible to make such comparisons with sea-level at the same point, because the tide gage at Sandy Hook, which furnished the datum plane in 1887, is no longer operating; while the tide gage at Fort Hamilton, which has been used to determine the modern datum plane, was not operating in 1887. Careful studies have, however, convinced Mr. Koop that mean sea-level has the same elevation both at Sandy Hook and Fort Hamilton, so that comparison between the two surveys can be made with accurate results. The following table gives the apparent differences in elevation of certain bench-marks after a lapse of 24 years, together with the differences which ought to exist if the land had been sinking at the rate of 1 foot or 2 feet per century, as commonly supposed. All differences are expressed in millimeters.

Bench-mark of	Apparent difference in 24 years mm.	Expectable difference, assuming 1 foot subsidence per century mm.	Expectable difference assuming 2 feet subsidence per century mm.
Bay Ridge, Brooklyn.......	—0.5		
Bath Beach, Brooklyn......	—1.2		
East 84th Street, Manhattan.	—0.7	73.0	146.0
Willets Point, Long Island..	—1.2		
College Point, Long Island..	—3.7		

When one considers that the probable error in determining mean sea-level at Sandy Hook was ±9.1 millimeters, it is seen that all the apparent differences are well within the limits of error of observation; whereas the exceptable differences according to the subsidence theory are so great that no errors of observation could obscure the subsidence, were it really in progress.

If the reader will pardon the personal reference, I will quote Mr. Koop's final conclusions verbatim: "From the determinations above noted, which are the result of spirit leveling of unquestioned accuracy, it is clear that from the standpoint of the geodesist or engineer there is no reliable evidence to show a general progressive subsidence of the Atlantic coast in New York City and

*Reprinted from the *Geographical Review*, published by the American Geographical Society, Broadway and 158th St., New York.

[1] *Annal. de Geogr.*, Vol. 21, 1912, pp. 193-212.

[2] *Annal. de Geogr.*, Vol. 23, 1914, pp. 193-218.

[3] *Norges Geol. Undersok. Aarbok*, 1915, Art. 4, 19 pp.

[4] *Trans. Nova Scotian Inst. of Sci.*, Vol. 14, 1916, Part I, pp. 109-119.

[5] *Bull. Geol. Soc. of Amer.*, Vol. 24, 1913, pp. 217-228.

[6] Report on Leveling, *Geol. Survey of New Jersey Bull. 6*, pp. 18-21, 1912.

vicinity. On the contrary, all the evidence is in favor of stability. . . . The work of the writer on the Board of Estimate leveling must be construed as a striking confirmation of Professor Johnson's theory of coastal stability as set forth in the preceding paragraphs. It is of especial interest because it is a proof based on engineering methods of the absolute stability during the last quarter of a century of the very part of the coast which is generally supposed to be undergoing most rapid subsidence at the present time."

Diastase in the Laundry*

By Wright Van Deusen

One of the most popular epigrams coined by the late Frank S. Black, when Governor of New York, referred to "taking the starch out of the Civil Service." Governor Black was a resident of Troy, the Collar City, and well knew that "taking the starch out" meant greater pliability, which is as good a thing in politics as it is in laundries. The phrase is commonly used, yet the only men who are literally concerned in doing that little thing have been, perhaps, the least effective in their efforts to accomplish it.

My experience has made me particularly well informed as to the technical and practical uses of diastase, or malt extract, in laundry operations. When I first became interested in this product I made a study of it, experimenting in custom laundries in the East, and in the great collar and shirt manufacturing plants in Troy. The results have been entirely in favor of a starch solvent in your industry, both as a matter of undisputed economy and of increased efficiency.

The steadily increasing cost of soap alone is enough to force serious consideration of this revolutionary product upon the attention of the laundry owner. How many, in these abnormal times, are wondering whether it is possible to increase prices further to meet the expense or whether it is better (I had almost written "necessary") to close up shop until a readjustment of conditions insures another lease of life?

In considering this subject it is important that one should know its component parts and all the advantages he should derive from its use. I refer to a liquid malt extract, a specially prepared form, high in diastatic strength, valuable in its power to convert starch into sugar, and especially adapted to laundry requirements in that it presents diastase in concentrated form, the only form in which a given degree can be developed to a certainty, which means guaranteed uniformity.

Being concentrated diastase, the instant it is placed in a temperature favoring fermentation, the enzymes become active. Having an affinity for starch, they attack the cells, combining to form liquid dextrine, which readily drains off in water. The amount of malt extract required in this conversion is determined as follows:

In new goods, before deterioration has set in through friction and other agencies, a dozen four-ply collars absorb seven-eighths to one and one-eighth ounces of starch, depending on the interlinings, which in some grades are heavier than in others. Knowing this, we estimate an average of one ounce of starch to the dozen collars, and then allowing for deterioration, find in 1,000 collars there is approximately four and one-half pounds of starch. Four ounces of 150 degree diastase contain enough enzymes to convert this. The benefits from use of this product are threefold:

First, as an aid in washing.

Second, as a preparation of goods for the proper injection of new starch.

Third, as a means of prolonging the life of starched fabrics.

In washing, the water may either be hard or soft. Diastase cannot be used in conjunction with soap, as it retards its life and if present in large quantities destroys it entirely.

A low water washing method is the most sensible. Cotton and linen collars absorb about 120 per cent of their weight in moisture, and can contain no more; hence, when the goods are once saturated, the process is merely that of forcing one element out and another one in its place. This is done through the friction caused by the rotary motion of the machine, and will carry much more force and favor if the elements are concentrated in a small body.

We start our wash in cold water, saturating the goods for five minutes, and then discharge. This eliminates the danger of setting such stains as oils, blood, etc., which should not come in contact with hot water at the outset.

One hundred degrees F. will cause enzymic action and thoroughly dextrinize starch, but the action is comparatively slow; therefore, to economize in time, we run in the wheel about three inches of water, between 130 and 140 degrees F., which creates the greatest activity, with the quickest results.

*The National Laundry Journal.

Ten minutes in this temperature will bring the goods to the same condition of cleanliness that is gained with a first soap, because the elimination of the starch releases every iota of dirt that had adhered to it. We also have the added advantage of a wide-open fiber, placing the goods in a receptive condition for the introduction of detergents, which instantly upon immersion will reach the stain in the softened fabric, not being hindered by a veneer of starch clinging to and filling the threads.

Therefore, one soap and bleach, combined in one water, and run twenty or thirty minutes, according to the soiled condition of the goods, will complete the cleansing feature of the wash, after which thoroughly rinse, sour and blue. In theory, with this formula, a little less acid will prepare the goods for the blue, as the quantity of alkali to be neutralized will not be so great. Blue will have to be used with less strength, because the free, soft fibers will take it more readily.

The sebaceous matter exuded by the skin pores causes yellow seams, and in its natural oxidized state prevents starch from being absorbed in ordinary process of washing. This leads to blistering, limpness, browning under the iron, and cracked collars. This chlorestrin wax, however, has no deterrent effect on the function of diastase, and the removal of the starch will come nearer to solving the yellow problem than any agency now in use. It certainly does assist.

A great many laundry owners and washmen believe that collars that apparently are cleared up after the acid and blue, are devoid of the matter causing the yellow. They are mistaken. There is a lot it held tightly in the fiber by the starch that had not been washed out. The seam appears clear enough at the moment, but in time the yellow matter will overcome the effect of the sour and blue, and reappear. Thus, as the collar is worn and returned to us, we have to contend not only with the new accumulation of yellow, but with the old as well, and with every subsequent wearing of the collar this condition becomes worse.

A few men still cling to the fallacy that water dissolves starch; but as I am writing this for the intelligent contingent, I need not go further than to remind you that raw starch, thoroughly mixed in cold water, is merely a mechanical solution, which, if left to stand a short time, precipitates, leaving the starch a pasty mass, at the bottom of the tank. Cooked starch, on becoming gelatinized and dried, is equally insoluble. Immersed in water, no matter how hot, it merely softens or swells, but is incapable of mixing with it. This is its condition in starched fabrics.

The ancient method of attempted elimination, which is the one many of you are still employing, was evolved the Monday following the day that starch was invented. Monday, you know, was the wash day of the ancients. They were content to use "elbow grease" in trying to push out some of the starch, so that they might reach the weave with their diluted ashes.

The old-timers must have been of a humorous nature, for they termed this interesting operation a "breakdown," and breakdown it was, and is! Forcing undissolved starch from the delicate fiber literally does tear some of the fiber away with it, and damage to goods subjected to this harsh treatment is greater than that caused by the use of alkali or bleach.

Wash starched goods; restarch and rewash, and continue this indefinitely. Then take goods that never were starched and subject them to exactly the same process—length of time run and ingredients used—and make your comparisons. You will find that unstarched white goods, badly soiled, do not require near as much time in washing as starched goods. The reason is obvious: No obstacle stands between the detergents and the stain and no time is wasted in their combinations.

The starch manufacturer, with the assistance of his chemist, carefully produces a product containing certain properties, every one of which is useful to you if used under ideal conditions. If you will not observe these conditions, and therefore only derive a portion of the benefits you paid for, the fault is yours. At the price the starch is offered you, you are entitled to 100 per cent of service. It is there, all right, as it stands in the barrel.

But even if you handle it perfectly in cooking, etc., you are counteracting some of its best properties by injecting it into a collar that already contains starch—old starch that has been subjected to several elements that do it no good; starch that is tenaciously clinging to and filling the fiber that you wish to reach with a better quality.

Under these conditions, the viscosity and penetrating powers of the new starch are impaired, and therefore uniformity is impossible.

A four-ply collar has a three-ply band, and there is a ten-ply seam where the top is inserted into the band. In washing, the ten-ply seam, containing the most starch and presenting the greatest resistance, will retain the largest amount of old starch, the four-ply top less, and the three-ply band still less. So, in restarching you must have different combinations of old and new, and where the greatest pliability is needed—in the seam—the least is secured.

The old starch remaining in the goods crystallizes under the heat and pressure of the ironing machine, and puts the fiber in a brittle condition; hence, when bent for passing through the finishing machine, it cracks. Remove the old starch, and with the uniform consistency of everything that is good in new starch, the collar will be so pliable that it can be bent between finger and thumb with little danger of damage.

One of the most convincing arguments favoring malt extract is the fact that 75 per cent of all the collars manufactured in America have been treated with it. A Troy concern, which launders as high as 275,000 dozen new collars in a single week, and whose system is the acme of efficiency, has, with its aid, reduced the loss in cracked collars to a degree that is negligible. The establishment is employing every conceivable means to prolong the life of the goods, and that it has succeeded in lowering damages to a minimum is evidenced in the fact that the inspectors, after the finishing operation, are given a bonus of two and a half cents for each defective collar found. These manufacturers are fortunate in having the services of a chemist who, as a specialist in all that pertains to linen, cotton and woolen fabrics, has not a peer in the wide world.

It is amazing how little laundry owners in general know about the manufacture of the goods they handle. The closest adviser to one of the leading luminaries in the laundry firmament, told me recently that there is absolutely nothing in common in the manipulation of collars in the manufacturer's laundry and in the custom laundry! And then he complacently sat back in his chair, secure in his ignorance, thinking that he had delivered a sledge-hammer blow at malt extract, one of the most scientific things ever successfully used in laundry operations! Of its merits, he was entirely ignorant.

The collar manufacturer always has a percentage of collars to relaunder, and in this branch he has exactly the same starch conditions to contend with as those that confront the custom laundry. The collar maker uses malt extract, or diastase, in precisely the same way as the laundry, and to attain the same object.

An Inexpensive Dialyser for Class Use

The glass dialysing frames are too expensive for use by classes in colloids. Even the goldbeater's skin to be stretched over these frames is not cheap. Such expense is a handicap on colloid research and discouraging.

If a very wide-mouthed bottle is at hand, the bottom may be cracked off by a hot wire on a file mark, a membrane tied over the lip on the mouth of the bottle and a good dialyser of trifling cost is ready. This type is not new, of course, but deserves to be better known. If a large number of rather small dialysers are needed, test tubes may be adapted by cutting off the bottom in the same way or heating and blowing out the ends. The lip on the test tube permits secure attachment of the membrane with a rubber band.

The cheapest and most easily made dialyser I have used, is a sheet of parchment paper shaped like a beaker. In other words it is all membrane having much greater dialysing surface than the usual forms. These beakers or cups can be shaped easily by any student. A sheet of parchment free from pinholes is soaked in water a few minutes to soften it and then folded over a bottle of the desired size and shape. The folds should be triangular, narrow and cover each other much as do the folds of an umbrella. It is best to crease them with firm pressure. A cord is tied around the paper and bottle about one centimeter from the upper edge and the whole set aside to dry. When dry the bottle is removed and the cup holds its shape perfectly. The cord must be left on the cup to support the sides. Two holes may be punched near the top of the paper and a string attached like the handle of a pail. So tough is the paper that a parchment cup holding a liter of water may be carried without tearing or collapsing.

To use such a dialyser it is nearly filled with the colloidal solution and suspended in a large vessel of pure water. Removal of ions is extremely rapid in spite of the fact that parchment is inferior as a membrane to goldbeater's skin. It is evident that with a given membrane the rate of dialysis is proportional to the effective surface of the membrane. In this form the bottom and sides of the cup are all effective.

The rate of dialysis may be doubled if two such cups are used, the smaller inside the larger. The inner cup holds pure water and the other the colloidal solution, while the combination of cups is hung in a larger vessel of pure water. This arrangement gives dialysing surface outside and inside the colloidal solution. The water may be changed as desired.—*Harry N. Holmes, Oberlin College, in the Journal of the American Chemical Society.*

On fire patrol duty at Squaw Peak Lookout Station, Montana

A ranger using the heliograph in the Custer National Forest, Montana

Protecting Our Timber Resources

Using the Heliograph to Fight Forest Fires

By Arthur L. Dahl

THE heliograph instrument as a means of communication has been used for a great many years, but its use has been almost entirely restricted to the Army. Interesting and successful experiments, however, were recently conducted by the United States Forest Service to extend heliograph communication to the work of discovering and extinguishing fires. Just as in our cities every effort is made by the fire department to reach the scene of a blaze at the earliest possible moment, so it is essential for the forest rangers to discover and take steps to fight forest fires as soon after they start as possible. In many of the western forests the country is so rough, and the distances so great, that telephone lines are impracticable, and some other means had to be devised to notify headquarters of a fire.

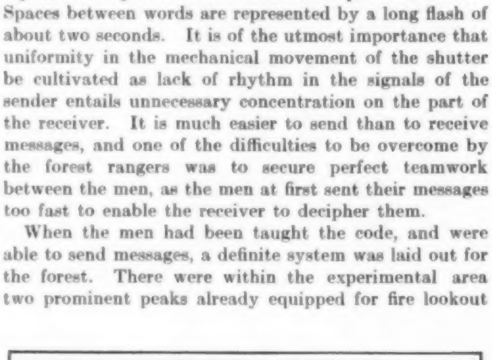
To test the adaptability of the heliograph to the fire patrol conditions some experiments were tried in the California National Forest in the northern part of California. A competent instructor was secured and seven men were chosen from among the rangers to learn the art of signaling. None of these seven men had any previous knowledge of the instrument, but they quickly learned the technical part of their work and became proficient operators in a very short time.

When the experiments were begun the only apparatus available was the standard heliograph instrument used by the Signal Corps of the Army. A number of these instruments were purchased and were used by the forest men. The instrument itself consists of two four-inch square mirrors and adjustable frames, a mirror bar, a sighting rod, a shutter and two hardwood tripods to the top of which the whole outfit is attached. The equipment is rather bulky and weighs approximately twenty pounds.

The principle of the heliograph is the reflection of the sun's ray steadily in a given direction, provision being made for alternately exposing and obscuring the mirror so as to transmit a series of long and short flashes. The instrument is set up at a point from which can be seen the station to be signaled. By means of the sighting rod and the tangent screws the instrument is sighted on the receiving station. The mirror is then so adjusted that the reflected ray is projected directly toward the station. The circle of illumination created by the mirror has a diameter which increases approximately fifty feet for every mile of distance from the mirror. For example: if the receiving station is six miles distant, the space at that spot within which the flash can be seen would be 300 feet wide. As the shutter is placed directly in the path of the reflected ray, flashes are transmitted by opening and closing the shutter. The actual manipulation is very similar to that used in telegraphing.

The best code for heliograph communication is the Myer code used as a standard by the Signal Corps. In a few instances the Morse code has been used for this purpose, but since it was created primarily for audible signaling rather than visible signaling it is not adapted for heliograph work. The Morse alphabet is based on a combination of ones and twos. For instance, the letter A is represented by 22, the letter L by 221, and the letter Q by 1211. The one in the Myer code is represented by a short flash. This means holding the shutter open for about one-half second. The two is represented by two shorter flashes in quick succession. Spaces between words are represented by a long flash of about two seconds. It is of the utmost importance that uniformity in the mechanical movement of the shutter be cultivated as lack of rhythm in the signals of the sender entails unnecessary concentration on the part of the receiver. It is much easier to send than to receive messages, and one of the difficulties to be overcome by the forest rangers was to secure perfect teamwork between the men, as the men at first sent their messages too fast to enable the receiver to decipher them.

When the men had been taught the code, and were able to send messages, a definite system was laid out for the forest. There were within the experimental area two prominent peaks already equipped for fire lookout



Detailed view of heliograph instrument set up on a lookout point. One mirror in use. The reflected ray of light from the mirror shows up plainly on the black surface of the closed shutter

work. Both peaks were connected by telephone with the Forest Supervisor's office and with the nearby rangers' cabin. In addition to these two principal peaks there were five smaller ones, also connected by telephone. The first two points were made the central stations, and two of the best men were stationed there. The other five points were designated as substations. These substations reported to the nearest central station, and since each forest officer was furnished with all locating instruments it was merely necessary for the substation to report the degree angle of the fire from its point and add a short statement of local description. A typical heliograph message would read: "Smoke bears 266 about seven miles on Rattlesnake Creek, near Bloody Rock. Just started. Burning in brush."

If the same fire was discovered by several operators each would send in a report, and by plotting the angle lines given in these reports would give the location of the fire, which would be at the point of intersection of those angles.

The average speed attained by the operators was four words a minute. As the average message need not exceed twenty words, it is seen that after discovering a fire a good heliograph man can notify headquarters within five minutes, whereas under the old conditions he would have to ride for an hour to reach the nearest telephone.

The range over which heliograph signaling may be effected on favorable atmospheric conditions is almost unlimited. By actual test it was found that perfectly visible messages could be flashed for a distance of 45 miles and read without the aid of a field glass. The only serious drawback to the use of this instrument is that on a cloudy day it is useless.

When it had been determined that the heliograph was valuable to the forest officers, the next step was to secure a more portable and less awkward outfit. After much experimenting the ideal instrument for the use of the forest men was designed. The instrument proper is made of aluminum alloy with certain parts of bronze. It fits into a small leather case approximately the size and shape of a 3A Kodak case, which very conveniently fits into the saddle bags on the horn of a patrolman's saddle. Instead of two heavy tripods, as in the case of the Army instrument, the new Forest Service instrument fits entirely on the head of one small tripod about twenty inches long and 2 inches in diameter. The entire equipment, including tripod and instrument, weighs about one-fifth of the standard instrument, and in bulk it bears the same relation. It was also found that by reducing the size of the mirror from four and one-half inches squares to three inches square no appreciable difference was made in the brilliancy of the flash. This afforded the opportunity of reducing the size of the whole instrument accordingly.

As fast as the rangers on the different California Forests can be taught to use the heliograph, they will be furnished with the new instruments, and on their rides through the mountains if a fire is discovered, they need only proceed to the highest available point and flash their signal to the surrounding districts.

The policy of preparedness is being carried out by the civil as well as the military branches of our country.

Flotation Experiments on a Transvaal Gold Ore

PYRITIC gold ore containing arsenic, from Barberton, crushed to 150-mesh and cyanided, gave a maximum extraction of 45 per cent; amalgamation proved a failure. Roasting followed by cyaniding gave 82.5 per cent recovery, but the high working costs militated against roasting. Concentration on a Deister table, with subsequent cyaniding of the concentrate, yielded 70 per cent recovery. Laboratory flotation tests were successful under the following conditions: The ore, crushed to pass a 90-mesh screen, was mixed with water in the ratio of 1:5, lime being added to produce an alkalinity of not more than 0.005 per cent CaO. The pulp was agitated for fifteen minutes with a mixture of wood creosote and paraffin oil. The middling and tailing were easily cyanided direct, the recovery being 22.1 per cent. The concentrate was roasted, then amalgamated and cyanided, with an extraction of 65.0 per cent. Allowing for volatilization losses on a commercial scale, the total extraction on this ore would be 84 per cent.—Note in *Jour. Soc. Chem. Ind.* on an article by F. WARTENWEILER, in *Jour. Chem. Met.* and *Min. Soc.*, South Africa.

An Experimental Study of a Theory of the Complex Zeeman Effect*

By A. E. Becker

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VARIOUS attempts have been made to account for the complex Zeeman effect. Preston's[1] suggestion that it may be due to complexity in the parent line has since been restated by Drude[2] and Bohr.[3] Wali-Mohammed[4] also suggests that the thallium λ line 5351 is really double, as it gives six Zeeman components which can be symmetrically arranged in two triplets. Apparently he does not extend the idea to other complex types. On the other hand, Paschen[5] has shown that narrow series doublets (or triplets), whose components give complicated magnetic effects for low fields, may combine into a single normal Zeeman triplet at high fields. The writer, however, has been led by his investigations on series spectra to an explanation identical with the suggestion of Preston. Even in the face of Paschen's work it seems worth while to present the results obtained by such a study of complex Zeeman effect.

The fundamental hypothesis is that the complex Zeeman effect is due to complexity in the structure of the parent line, which is supposed to consist of a number of components of equal or nearly equal frequency. Each of these gives rise to a Zeeman triplet of normal or nearly normal type. It is assumed that the number of components in the parent line equals the number of p-components (*i. e.*, Zeeman components polarized in a plane perpendicular to the lines of force). Each of the latter is accompanied by two s-components (*i.e.*, Zeeman components circularly polarized about the lines of force), exactly as in the simple effect. Such a triplet will be called a reduced triplet. It is not maintained that the p-components are necessarily at the positions of the parent-line components, for in that case change of field-strength would not affect their positions, which is contrary to experimental fact. The inference is that the number of p-components is the same as the number of components in the parent line, and vice versa. Thus the application of the hypothesis leads to an investigation of the two propositions:

1. In any complex Zeeman effect the number of s-components is always twice the number of p-components.
2. These Zeeman components may be arranged in symmetrical reduced triplets, one for each p-component, of normal interval.[6]

APPLICATION OF THE HYPOTHESIS

Let us first study the established complex types as illustrated by Voigt,[7] a reproduction being given in Fig. 1. The continuous vertical line in the middle of this diagram indicates the positions of the parent lines. Two parallel lines are drawn at a normal distance, a one on either side of the central one. The letters p and s denote the p- and s-components respectively. A', A, A'': B', B, B'', etc., indicate respectively the components of the reduced triplets. In any given type these triplets are all of the same interval. This is given in terms of a at the right of the types in Fig. 1.

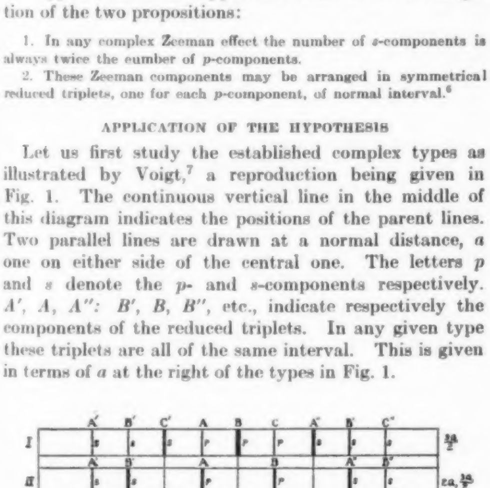
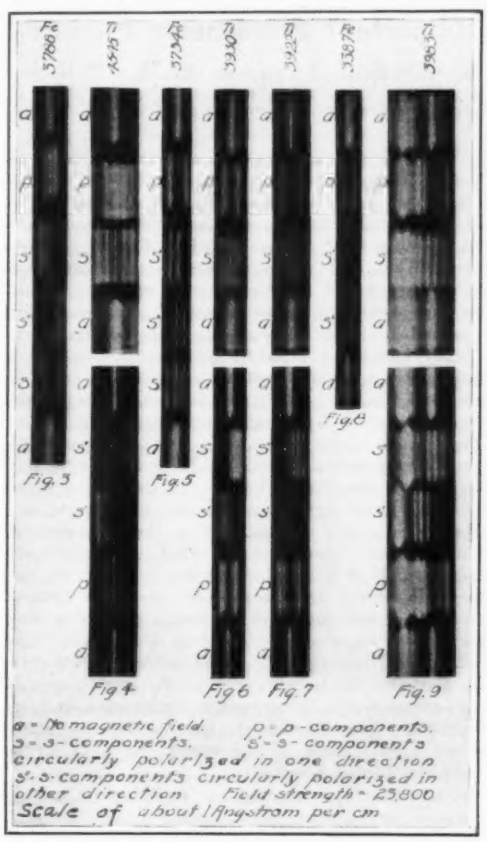


FIG. 1

It is now evident that type I reduces to three triplets, as it has three p-components, A, B, and C, together with the necessary six s-components, A', A'': B', B'': and C', C'', all properly placed. Type III is a triplet. It is obvious that type IV reduces to three triplets; type V, to three; type VIII, to two; type IX, to three; type X, to three; and type XII, to five.

In type VI one encounters difficulties. But Runge and Paschen,[8] who established these various types, seem to have been uncertain of the number of components in this one. It must therefore be regarded as an exception needing further experimental investigation.

Since type II has two p- and four s-components, it satisfies proposition 1. But the reduced triplets are unsymmetrical, the interior s-components, A'' and B', and the exterior ones, A' and B'', being respectively at intervals $2a$ and $3a/2$ from their p-components, A and B. Thus type II is an exception to proposition 2. But it is significant that these unsymmetrical displacements are those of the reduced triplets of types III and I respectively; for, as Voight,[9] points out, any three parent lines which give rise to types I, II, and III, respectively, are closely related from the standpoint of series spectra. And Paschen[10] shows that series combination terms of the form $(np_2—mS)$ give Zeeman triplets of interval $3a/2$, which is also significant, since np_2 is taken from the formula for lines giving type II. Similarly, type XI may be regarded as four unsymmetrical reduced triplets, the displacements being $7a$ 5 and $6a$ 5.



Type VII satisfies neither proposition. But by assuming two s-components, as yet unobserved, at the position of the parent line, it reduces to two symmetrical triplets of interval $2a/3$, which is just half that of those in type VIII. Thus the assumption has merit, since series spectra again show that parent lines giving rise to types VII and VIII are very closely allied. One would thus expect each of these parent lines to be close doublets, which is the conclusion of Michelson[11] and others for the D_1 and D_2 lines.

The assumption of the superposed s-components in type VII affords opportunity to appeal to experiment. Along the lines of force only the s-components are visible. By analogy with the simple effect, the primed s-components of the reduced triplets should be circularly polarized in one direction and the double-primed ones in the other. The interesting case is that in which a circularly right-handed polarized component falls on a circularly left-handed polarized component, as in type VII at the assumed central s-component. Such a double component should be unpolarized when viewed along the lines of force.

We have thus found that of the twelve types of Fig. 1 eight satisfy both propositions 1 and 2; two others satisfy proposition 1; another requires further experimental investigation; and the remaining one points out the method for a beautiful experimental test of the truth of the two propositions.

If the assumed s-component of type VII really exists, it is probably of weak intensity and thus rather unsuitable for examination along the lines of force. However, a study of King's[12] results for iron and titanium shows that several complex types afford opportunity for carrying out the experiment. A convenient type is that illustrated in Fig. 2, where a represents the parent line; b, the p-components; c, the s-components at right angles to the lines of force; d, the s-components which one expects to be circularly polarized in one direction; and e, those in the other. That is, one expects the central s-component to be unpolarized along the field.

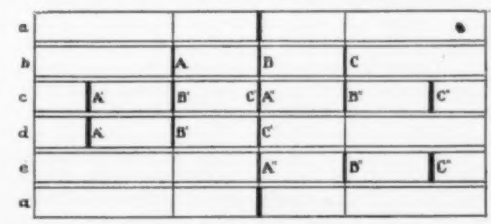


FIG. 2

This expectation is verified experimentally, as shown by the writer's photographs, Plate I, Figs. 3 and 4. Another type which occurs several times in both spectra is that of Plate I, Fig. 5, which again has the central unpolarized s-component. It thus has four s- and two p-components, as called for by proposition 1. Fig. 6, on the same plate, presents another type, which is seen to consist of twelve components instead of eleven, as it appears when viewed at right angles to the field. The same is true in Plate I, Fig. 7, except that the central s-components are not exactly superposed. A further verification of proposition 1 is shown by Plate I, Figs. 8 and 9, in each of which there are two of these unpolarized s-components, thus giving eight s- and four p-components. Becquerel and Deslandres[13] had already discovered the unpolarized s-component in Plate I, Figs. 3 and 5, but the writer was able to predict that there would be two of these unpolarized s-components in cases such as shown in Plate I, Figs. 8 and 9. There are several other types, especially in titanium, which is the same way verify the hypothesis that there are twice as many s- as p-components in every complex Zeeman effect.

To test the hypothesis in another way, the writer repeated the experiments of King.[14] A field of 23,800 gausses was used, the investigation extending from λ 5050 to λ 3230 for iron and titanium. Some of the complex types found do not agree with King's results. In titanium the region common to both investigations is from λ 5050 to λ 3659, for which King records 165 Zeeman triplets, 23 lines showing complex effects, 1 unaffected line, and 133 lines whose Zeeman effect was doubtful. For the same 322 lines the writer finds 157 Zeeman triplets, 45 lines showing complex effects, 1 unaffected line, and 119 lines of a doubtful number of Zeeman components. Thus the writer finds a larger number of lines of complex Zeeman effect, in which the components are photographically well-defined and sharp, than does King.

Between λ 5050 and λ 3230, the writer finds in titanium 67 lines showing complex Zeeman effects of unquestionable charater. Of these lines 62 have twice as many s- as p-components and therefore satisfy proposition 1. Of the remaining 5, 3 are apparently quartets, 1 an octuplet, and the other a quintuplet having but one p-component. This latter may be regarded as two reduced triplets in which the p-components for some reason do not separate when the field is applied. There is also the line λ 4296 which is apparently unaffected by a magnetic field. Careful measurements show that of the 62 lines of complex Zeeman effect which satisfy proposition 1, 70 per cent can be reduced to symmetrical triplets and thus satisfy proposition 2. Similar results are obtained for the iron spectrum.

APPARATUS

To carry out the experimental work a large concave grating of 21-foot focus, 20,000 lines per inch, and a 6-inch rule surface was used. The form of mounting is that of Paschen at Tübingen, the grating and slit being fixed. The spectrum can be examined from λ 2000 in the first order to λ 7000 in the second; thus photographs may be taken simultaneously in both orders. The grating remains in perfect adjustment for long

*From *The Astrophysical Journal.*

[1] *Dublin Society Transactions*, 6, 385, 1898; *Philosophical Magazine*, 45, 331, 1898; *Nature*, 59, 224, 1899.

[2] *Theory of Optics*, p 447.

[3] *Philosophical Magazine*, 27, 518, 1914.

[4] *Annalen der Physik*, 39, 248, 1912.

[5] *Ibid*, 39, 897, 1912.

[6] In this connection the reader will find the article by Ritz (*Annalen der Physik*, 25, 676, 1908) of importance.

[7] *Magneto-und Electro- ptik*, p. 87.

[8] *Astrophysical Journal*, 15, 235, 1902.

[9] *Loc. cit.*

[10] *Loc. cit.*

[11] *Philosophical Magazine*, 34, 290, 1892.

[12] King, "The Influence of a Magnetic Field upon the Spark Spectra of Iron and Titanium," *Carnegie Institution of Washington, Publication No. 153*, pp. 22-42.

[13] *Comptes Rendus*, 127, 18, 1898.

[14] *Loc. cit.*

periods of time, it now having been used for more than a year without readjustment. The temperature of the grating-room remains so constant that exposures of several hours are successfully made.

The source of light was an electric spark. A condenser of variable capacity from 0.01 to 0.06 m.f. was used in the oscillatory circuit, the spark length being about half centimeter. The use of self-induction was avoided.

The earlier experiments were made with an electromagnet giving a field of 14,000 gausses with a gap of 8 mm. A Weiss electromagnet is now in use which gives a field of 23,800 gausses for a gap of 12 mm. This is especially convenient, since it can be rotated so that the spectrum may be examined along the lines of force or at right angles to them.

At right angles to the field a nicol prism is used to separate the p- and s-components. Along the field a Fresnel rhomb and a nicol prism are used to separate the two kinds of circularly polarized components. All of these components, as well as comparison spectra, may be obtained on the same negative by means of a slit diaphragm placed on a separate holder immediately in front of the plate-holder.

SUMMARY

Some work on series spectra, which the writer hopes to publish soon, led him to suspect that certain spectral lines are in reality close doublets, and that therefore they may be expected to show a complex Zeeman effect consisting of two p- and four s-components. This is indeed found to be the case. Conversely, the writer conceived the idea, independently of other investigators, that complex Zeeman effects occur because spectral lines which give rise to more than three Zeeman components are themselves complex in structure, and that the number of components in such a parent line is exactly equal to the number of p-components which it shows when placed in a magnetic field.

Investigation has shown that, in the titanium spectrum between λ 5050 and λ 3230, 62 out of 67 lines of complex Zeeman effect have twice as many s- as p-components; and that at least 70 per cent of these may be reduced to symmetrical Zeeman triplets, one for each p-component. In each complex type the reduced triplets are all of the same interval, which varies, however, from type to type in the same manner as for ordinary Zeeman triplets. Further study led to the prediction that in certain cases there are present one or more s-components which should appear unpolarized when viewed parallel to the field. This has been verified experimentally.

Several important questions still remain to be solved. One is the reason for the unsymmetrical distribution of the intensities which frequently occurs in the components of the reduced triplets. Another is that of the separation of the p-components when the magnetic field is applied. A third is that of the abnormal Zeeman intervals. But the same fundamental cause which gives rise to ordinary abnormal Zeeman triplets is probably responsible for the abnormal intervals of the Zeeman triplets to which the complex types may be reduced.

In conclusion, the writer wishes to recognize the valuable help of Prof. Theodore Lyman, of Harvard University, under whose supervision this work has been done. His many suggestions, particularly as to the best method of presenting the subject, have been invaluable.

The Electrical Properties of Gases—II.*

Which Enable Important Problems in Physics To Be Studied

By Sir J. J. Thomson, O.M., P.R.S.

CONTINUED FROM SCIENTIFIC AMERICAN SUPPLEMENT NO. 2167, PAGE 27, JULY 14, 1917

III

In his opening remarks Professor Thomson said that in his last lecture he had explained the results obtained by Mr. C. T. R. Wilson in his measurements of the electrical effects of thunderstorms. It thus appeared that in quite an ordinary storm some 30 coulombs of electricity passed with each flash from the cloud to the earth. He had since been asked if this observation could be reconciled with Faraday's conclusion that the total quantity of electricity in movement in a storm was comparable with that which could be obtained from a thimbleful of matter. It might therefore be interesting to put into figures what quantity of matter would be required to furnish 30 coulombs of electricity. The charge of electricity on the hydrogen atom was, in round numbers, 1.5×10^{-19} coulombs. Hence the number of atoms required to furnish 30 coulombs would be $\frac{30}{1.5} \times 10^{19} = 20^{19}$ atoms, or 10×10^{19} hydrogen molecules. In one cubic centimeter of hydrogen at standard temperature and pressure there were 2.75×10^{19} molecules, so that $\frac{10}{2.75} = 3.64$ cubic centimeters of hydrogen would be the amount of gas required to furnish the 30 coulombs of electricity.

He did not know whether Faraday's dictum had been quoted as a taunt to the thunderstorm or as a compliment to the electrical properties of matter. It had, however, to be observed that there was a great difference in the potential of the 30 coulombs bound up in 3.78 c.c. of hydrogen molecules with an equal amount of electricity of the opposite sign, and that of the same quantity in a thundercloud some miles above its corresponding positive charge. It was not possible to produce much in the way of electrical effects with even a large charge of negative electricity if it lay closely adjacent to an equal positive charge. The sole difficulty in getting such effects was to separate the two kinds of electricity, and this required the expenditure of work.

It was possible from Wilson's observations to find out upon what area of cloud the flash drew for the 30 coulombs it carried to earth. We knew how much electricity was required per square centimeter of surface to furnish an electric force strong enough to produce a spark. This amount was $\frac{8}{3} \times 10^{-9}$ coulombs, which therefore represented the charge on a square centimeter just before the flash. The area required to provide 30 coulombs was accordingly $\frac{30 \times 3}{8} \times 10^{9}$, or, roughly, 10^{10} sq. cm. = 1 sq. kilometer.

A peculiarity of the phenomenon was that the whole quantity came down in a single thread. The diameter of the flash was unknown, but was certainly not very large, and with this concentration of energy in a discharge of small cross-section it was easy to understand that enormous mechanical effects might be produced. These were, in fact, the speaker continued, considerable even with small-scale apparatus. This he demonstrated by placing a glass bulb, about 1½ inches in diameter, filled with water between the two terminals of a large Wimshurst electrical machine, which were some 10 inches apart. On operating the machine the bulb was shattered to pieces by the spark.

He wished, the lecturer proceeded, to consider next a very interesting problem, a satisfactory solution of which had not even been approached till within the last few years. What, in short, was the mechanism involved in a thunderstorm? and how did Nature work to produce this huge electrical machine capable of giving sparks six or seven miles long? How was the energy accumulated? In reply, he might say that for long there had been little doubt as to an essential part being played by water. It was not actually necessary that rain must occur at the same place as the lightning, but there must be rain or heavy clouds in the neighborhood. All theories of the thunderstorm looked to rain or clouds as in some way the origin of the storm. Lenard was the first to throw light on certain properties of water which were now believed to play a leading part in the generation of thunder-storms. Lenard found that whenever there was splashing of water electrification resulted, the two electricities being separated. This effect the lecturer showed by directing from a Goudie sprayer a very fine spray of water on the plate of an electroscope. The immediate divergence of the leaves showed that the plate was electrified by the spray. The charge on the plate was positive, but the air around the spray was negatively electrified. This experiment, the speaker continued, provided the essence of the modern view as to the production of thunderstorms.

It had long been known that there was something abnormal in the electrical conditions at the foot of a waterfall, which was in fact the source of some electrical disturbance, but the matter was not thrashed out until Lenard investigated it and showed that the water was positively electrified and the air negatively. He further showed that this electrification was extraordinarily sensitive to minute traces of impurity in the water. These might change not merely the amount of the electrification, but even its sign. Thus a trace of methyviolet too small for its presence to be detected by the eye would greatly affect the amount of electrification produced by a spray. This was, the speaker said, the more notable, since the coloration produced by methyviolet was so intense that it was frequently used for tracing out the flow of underground streams. This sensitiveness of the spray to impurities was discovered by Lenard, who found it impossible to repeat at Bonn experiments he had successfully made at Heidelberg, where the water supply was much purer.

Later experiments had carried the matter further and established a point which was fundamental in the theory of the thunderstorm. It had, in fact, been shown that whenever a drop of water split up, whilst still suspended in the air, the water of the drop was positively electrified and the surrounding air negatively electrified. Hence any process by which big drops were broken up into little ones, whether by clashing against each other or in other ways, constituted a potential source of electricity. It had been shown that if the surface of pure water was increased an electrical effect was produced. This was accounted for by the view that in its normal state a water surface covered itself with a coating of negative electricity which tended to stop the emission of further negative particles from the interior. If the surface were increased there would be nothing to stop negative particles coming out from the water to form a new coating. In this process some escaped and rendered the surrounding air negative, whilst the water became positively charged by the loss of these negative particles.

This electrification produced by the breaking up of a jet of water into a fine spray the speaker illustrated further by a very striking experiment. A fine jet of water was led through an orifice in the centre of a tin bath and rose vertically some 6 feet or 8 feet into the air before it broke up and fell back into the bath. In normal conditions the spray was so fine that the sound made was barely perceptible, but on bringing near the jet an ebonite rod electrified by friction the drops immediately became bigger, producing a very audible patter as they fell into the basin below. The jet, moreover, rose higher into the air before breaking up. In still another experiment the shadow of two jets of steam was thrown on to a screen, and it was shown that the shadows became much darker when a wire at the center of the orifices from which the steam escaped was coupled up to an induction coil.

The foregoing experiments showed that condensation was promoted and larger drops formed by the electrification. The application of these considerations to thunderstorms which he was about to make would, the speaker said, be found, for the most part, set forth at length by Dr. Simpson in vol. ccix of the Philosophical Transactions of the Royal Society.

In the first place everyone must have noticed that raindrops never approached in size the dimensions of the largest hailstones. All sorts of statements were to be found as to sizes attained at times by the latter. The lecturer had himself found in one meteorological paper a statement that certain hailstones were as large as oranges or melons. Taking the most moderate estimate of the size of a melon, nothing even approaching such a figure was attained by a raindrop. The size of the latter had, in fact, a sharply defined maximum value, the diameter, very rarely, if ever, exceeding 5.5 mm.

The actual diameter was difficult to measure, but the evidence was strong that there was this definite limit of size. In short, if a big drop began to fall through air it was flattened into a more or less disk-like form by the resistance experienced. It thus exposed a large surface very liable to disturbances, which differed from point to point. These caused the break up of the drop, with the result that even a drop of 5.5 mm. diameter could not exist for more than a few seconds. Every time a drop broke up electrification was produced, each drop acting as a little electrical machine. In the case of hail there was no instability produced by an increase in size, and hence large hailstones were possible.

Before a thunderstorm there was somewhere or other a strong upward current of moisture-laden air. As this rose it got cooled, so that the moisture was deposited in drops. Unless these drops exceeded a certain size they would be borne up with the rising current of air. Suppose, however, that they were such a size as to be just supported, falling down just as fast as the current carried them up. If they got any bigger than this by further condensation they would fall, and in doing so

*From a report in *Engineering*.

break up into smaller drops. In this process the surrounding air would be negatively charged, and this charge would ultimately be transferred to the smaller droplets or spray formed on the break up of the big drops, while the larger residues would be positively charged. The small droplets, with their negative charges, were then carried up with the ascending current of air, which was unable to move the heavy larger drops. The two charges were thus separated, all the positively charged drops remaining at the bottom of the cloud, while the light negatively charged spray was carried up by the current against the attraction of the positive charges left behind. The result was that the bottom of a thundercloud bore a strong positive charge, while the negative electricity was carried up to the top of the cloud. Between the two a very strong field was established, and this field, it would be seen, was the outcome of the peculiar property possessed by water of setting free electricity whenever a drop broke up. The strength of the field increased as further charges were liberated, until finally a spark passed from the top to the bottom of the cloud.

If there was a horizontal current of air at the top of the cloud the charges would be separated horizontally as well as vertically, and in that case the strong field would be established between each part of the cloud and the earth immediately below it. The discharge would then take place from the cloud to the earth.

Summing up, it would be seen that the process of producing a thunderstorm commenced on the breaking up of large drops of rain into smaller drops and fine spray. The latter picked up negative charges from the surrounding air, and the work of separating this spray from the positively charged drops was effected by air currents. If these were wholly vertical the discharge took place within the cloud, but if at the top of the cloud a horizontal wind was experienced, the top and bottom of the cloud were separated horizontally, and a field established between each component and the earth below. The flash in that case passed from the cloud to the earth.

In the foregoing explanation he had, Sir Joseph proceeded, utilized but one of the various ways in which drops and spray acquired charges. In violent storms however, the drops might knock against each other, and we might then get the effect of a little induction machine. Thus consider a drop in the electric field between the top and bottom of the thundercloud. By induction the top of the drop would be positively charged and the bottom negatively, and the drop would, moreover, elongate under the stress thus produced. If, then, the bottom of this drop were knocked off as the result of a collision, and was forthwith carried up by the air current, the arrangement would be the exact equivalent of an induction electrical machine.

If the views above set forth were correct we should have a patch of cloud constituted at the bottom of large positively charged drops. If, then, the upward current failed, these big drops would fall as the very heavy rain which was so frequent a concomitant of a thunderstorm, and these big drops should be positively charged. A great many experiments had been made to determine the kind of charge carried down by the raindrops which fell during a thunderstorm. The experiment was not an easy one, since if the drops were allowed to splash they would liberate negative electricity. There was, nevertheless, evidence that although the rain was sometimes positively charged and sometimes negatively, yet the heavy rain was always positively charged. Sometimes fine showers followed the heavy rain, and in this case the fine drops were negatively electrified.

As for the lighting, Wilson had found that sometimes it carried to earth a positive charge and at other times a negative one. This was quite in agreement with the view which attributed a discharge to earth to the drifting apart horizontally of the top and bottom of a thundercloud. The whole phenomenon was, it would be seen, due to the action of a kind of wind and water mill. Both water and wind were essential, the wind being necessary to carry the spray above the large drops or to knock the latter together, or to break them up if too big.

One remarkable effect sometimes seen had not been touched on in the foregoing theory. This was the thunderbolt or globular lightning. For his own part he had, Sir Joseph went on, never seen it himself, but there were a great many records of such experiences, constituting overwhelming evidence as to the occurrence of the phenomenon. In some cases a luminous ball was seen slowly falling to earth, disappearing when it reached the ground. In some statements this disappearance was said to be accompanied by a loud bang. So far this effect had not been satisfactorily explained. Another effect recorded was the running along the ground of a sort of luminous football. This might be merely a brush discharge over a line of metal piping under the surface of the ground, and was quite distinct from the globular lightning described in other records, which fell slowly from sky to earth.

What seemed to the speaker the most probable explanation was that this globular discharge differed in kind from the flash. The latter had, to begin with, to ionize the gas through which it passed, and it left its track in a conductive condition. An immediately succeeding discharge would therefore meet with quite different conditions, the track having been already prepared for it by the flash. The current in this discharge would, accordingly, not reach the same intensity as in the flash, but be more analogous to a continuous discharge.

To illustrate the resultant difference the lecturer took a discharge tube, and passed through it an intermittent current of such a periodicity that the ionization produced by one discharge had disappeared before the next followed. Each discharge had therefore to prepare its own track. In these circumstances the appearance of the tube was uniform from top to bottom, no one point being more luminous than another. A current of much higher frequency was next passed through the same tube, and in this case there were marked differences in the appearance of the glow, striae, or alternate patches of brightness and darkness, being very visible in the upper part of the tube. The difference was due, the lecturer stated, to the fact that in this second experiment the effects of one discharge had not died away before the next came.

Globular lightning, in his view, was accordingly a slow continuous discharge, with the peculiarity that the luminosity was concentrated into a ball. It was, moreover, possible to produce a discharge tube in which the luminosity was concentrated into a ball, and this ball could be caused to travel up and down the tube. This experiment the lecturer showed with a vertical discharge tube fitted with a Wehnelt cathode. By suitably adjusting the resistances in the same circuit with the tube, the discharge took the form stated, and was caused to shift up or down the tube at will.

This was the closest analogy he could find in the laboratory. He had, however, never himself seen the phenomenon of globular lightning, but the records left no doubt as to its existence, though the evidence was less satisfactory as to its ultimate disappearance with a loud explosion, or that it got into rooms and blew the windows out when it burst. The sulfurous smell, also recorded, appeared quite likely, being attributable to the formation of oxide of nitrogen. Those who had the fortune to see it should note the rate of fall and whether the globular discharge followed immediately after a flash. It need not necessarily follow the same path as the flash, since the ionized channel produced by the latter might be drifted some way off by the wind.

[*To be continued*]

The Compression of the Earth's Crust in Cooling

The principal cause of the elevation of continents and mountains has been ascribed by geologists to a state of horizontal compression of the earth's crust under which it frequently gives way, the strata being then folded into a shorter length in the neighborhood of the point where the weakness has been shown. Such a compression appears to be the only mechanism that has been suggested to be qualitatively capable of producing the observed results. The cause of the compression itself is, however, very uncertain. The contraction hypothesis is the most satisfactory of those that have been offered, but grave doubts have frequently been expressed about its quantitative adequacy. Previous estimates by G. H. Darwin and Davison rested on Kelvin's theory of the cooling of the earth. From radioactivity considerations, however, it has been shown that so much heat is actually being generated within the earth's crust, that if the same amount per unit volume were being produced throughout the mass, the temperature gradient at the surface would be 300 times its actual value, and the earth would be getting hotter instead of colder. There are many objections to this view, and it seems that the amount of radio-active matter per unit volume must decrease so rapidly with depth that the total is insufficient to supply more than about three-fourths of the present loss of heat from the surface. From a review of the evidence obtained by several different lines of investigation, Holmes has found that the observational data can be satisfied exceedingly well if the age of the earth be taken to be about sixteen hundred million years, and if the rate of liberation of heat per unit of volume decrease exponentially with the depth. The interval of time concerned is so much greater than that found by Kelvin that his theory of cooling requires to be revised so as to take into account our most recently acquired data, and at the same time the contraction theory, which depends on it, needs similar revision. This is the principal object of the present paper.

The level of no-strain is found now to be at a considerably greater depth than the older determinations gave, and at the same time the amount of compression at the surface is much increased. For both reasons the volume of crumpled rock is increased. On the basis of the exponential distribution of radio-active matter the available compression is 133 km., *i. e.*, enough to shorten every great circle of the earth by this amount. Actually, folding is not uniformly distributed over the earth, but nearly confined to certain definite lines of weakness, and in the valleys of East and Central Africa a tension is actually indicated. Some great circles thus show very little crumpling, and others are free to be folded to a greater extent than would be possible if the distribution of mountains were uniform. When a numerical estimate is made of the amount of compression required to produce the known mountain ranges, that found to be available on the contraction hypothesis appears to be quite adequate. The author gives a mathematical investigation into the effect on underground temperatures of a uniform distribution of radio-active matter through a horizontal layer, as also of other distributions of radio-active matter where the restriction is removed that the liberation of heat by such matter is assumed to be given by a special law of uniform distribution down to a particular depth and zero below. If it be assumed that throughout the process of cooling the earth preserves a state of spherical symmetry, then since the changes of temperature are not the same at all points, a state of strain must be set up consequent on the variations of volume that take place. This straining of the crust in cooling receives detailed mathematical attention. An examination of the amount of compression required to produce existing mountains is also undertaken. The author states that the elevation of a continent or a large tableland involves little crumpling within it, and no great amount at the coast so long as the slope is there gradual, so that in determining the amount of compression only the steep slopes of mountains need be considered. The theoretical and observed compressions are of the same order of magnitude; it thus seems highly probable that the contraction hypothesis is adequate to account for a very large fraction of the mountain-building that has taken place, and perhaps for the whole of it. The influence of denudation and thermal blanketing is examined at some length. An oceanic area is found to require round its margin a smaller horizontal pressure than the mean if it is to remain spherical, while a continental area requires a larger pressure. As the pressures must be equal, it follows that the earth cannot remain spherical. The only way in which this can happen is by a reduction of the radius of curvature of the crust, *i. e.*, the continents will tend to rise and similarly the ocean-bed will sink. The effect capable of being thus produced is very great. The adjustment of the figure of the earth to make the compression constant all over is not likely to be complete and the remaining part of the differential compression will be shown in extra folding in the continents, and diminished compression, or even, in extreme cases, a tension in the ocean-bed. A section of the paper is devoted to the causes of isostasy, and the author goes into the difficult problem of how the continents and ocean basins ever came to be formed. If there were no isostatic compensation, they might be attributed to crumpling by compression of a type not very different from that which produces mountain ranges. Continental areas, though varying enormously in height and shape, are fairly permanent in position and their height is really due to their being made of lighter materials than the ocean-bed. The question is to decide how the lighter materials succeeded in being collected to certain points, leaving the denser rocks exposed in other parts, and Jean's theory of Gravitational Instability, which the author considers to be the most satisfactory extant, is examined at some length. The concluding section is devoted to the effect of changes in the rotation of the earth. The truth of the theory of Tidal Evolution follows as a natural consequence of the present paper, and must, therefore, be considered with it.—A note in Science Abstracts on an article by H. Jeffreys in the *Philosophical Magazine*.

Removing Rust by Electricity

An electrolytic process of deoxidation has been patented in the United States. The object to be treated is made the cathode in an electrolyte containing phosphoric acid. In addition to its normal function of carrying the current, this acid acts as a solvent upon rust without attacking the steel or iron body beneath. It is in this last detail that its chief availability lies, since nitric, sulphuric, or hydrochloric acids would not display such moderation. Finally, the phosphoric acid is beneficial in preventing subsequent further rusting. The electrolyte is made by adding 10 parts of phosphoric acid to 90 parts of water, or by adding 10 per cent of the acid to a 10 per cent solution of sodium phosphate. A temperature between 50° and 70° C., is recommended.

Tree and Plant Pests*

They Do Millions of Damage Every Year

By C. L. Marlatt, Chairman, Federal Horticultural Board

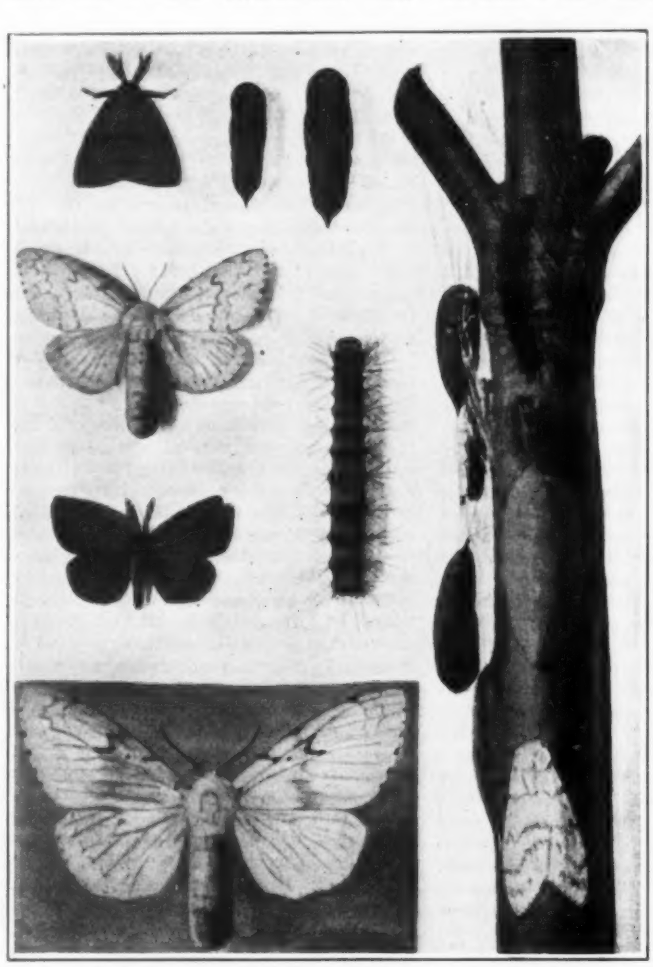
THE virgin lands of the new world had originally an enormous advantage over the long-settled areas of the old world in their freedom from the host of plant enemies, insects and disease, which had developed through centuries of cultivation of special crops, and, if proper safeguards had been instituted, this advantage could have been largely preserved. Unfortunately, none of the countries of the new world, until very recently, took any precautions to prevent the introduction of these old-world plant enemies.

Confining our attention to the United States particularly, as a result of this neglect, probably more than 50 per cent of the insects and diseases now destructive to our agriculture and forestry are introductions, most of them unnecessary.

Typical examples of these introduced pests, in relation to general agriculture, are the Hessian Fly, introduced from Europe in Revolutionary times and now occasioning an average annual loss to the wheat crop of approximately $50,000,000, and in some years this loss has exceeded one hundred millions; the alfalfa weevil, a pest of comparatively recent introduction getting a first foothold in Utah, from whence it has extended its devastations over much of the great alfalfa producing areas of the adjoining states. Among the fruit insects are such well-known enemies as the codling moth, now entailing a cost for the treatment of trees and loss from injury to fruit taken together of approximately $16,000,000 a year; and the San José scale introduced with ornamental plants from North China, occasioning a loss in product and cost of treatment of at least $10,000,000 a year. Among forestry insects are such notable enemies of forest trees as the larch sawfly, which threatens to complete the destruction already largely accomplished of the larch timber of the United States and Canada, and the gypsy and brown-tail moths, which have long ravaged the forests of New England and have been the occasion of the spending of many millions of dollars in control efforts and of losses proportionately vastly greater. For mere control alone, the Federal Government has carried an appropriation for many years now of over $300,000 a year to aid the States in the work against these insects. Other notable forest and shade tree pests are the spruce twig moth, a comparatively recent introduction, the leopard moth, and the elm beetle.

Pupating Larvae of the Asiatic Ladybird (*Chilocorus Similis*)

This beneficial insect, which is a voracious feeder on the San Jose scale in China and Japan, was introduced into the United States to assist in the control of this scale insect, and is helping to prevent destruction amounting to several hundred thousand dollars a year.



Various stages of the Gypsy Moth (*Porthetria Dispar*)

The gypsy moth is one of the worst forest pests of Europe. It was accidentally introduced into Massachusetts 40 years ago, and has now spread to the adjacent States of Connecticut, Rhode Island, New Hampshire, and Maine. It has been recently brought into this country on imported stock and taken to such widely isolated points as Louisiana and Ohio. There is grave risk of its becoming distributed over the entire United States. It has already cost in New England, in mere efforts at control, a good many millions of dollars, and should it become widespread in the United States, damage from it would be beyond calculation.

These are merely examples of a vast horde of introduced insect pests. Upwards of a hundred distinctly important insects injurious to agriculture and forestry have been thus introduced, and, in addition to these, hundreds of other minor insect pests. The total loss occasioned by these introduced insect pests to our national forests and farm crops, etc., probably exceeds $500,000,000 annually.

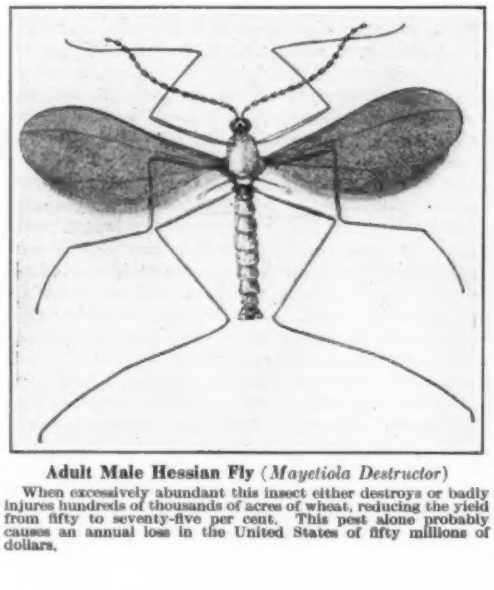
Losses correspondingly large are chargeable to introduced plant diseases. Familiar examples of such introduced diseases are: the chestnut blight, which has already destroyed the chestnut forests over much of the eastern United States and threatens the existence of the entire native chestnut growth of the country; the white pine blister, a disease already widespread in the eastern white pine area and which ultimately will cause enormous loss to all white pine forests, and which losses will be vastly increased should it spread to the great white and five-leaved pine forests of the Rocky Mountain and Pacific Coast States. Introduced diseases affecting cultivated plants include such important examples as the common scab of the potato, of almost universal occurrence in this country and occasioning tremendous shrinkage in the value of this important crop; the wheat rust, which in bad years may practically wipe out the entire wheat crop of large sections, as was the case last year in Red River Valley; and a corn mildew recently introduced and already accomplishing very serious losses in the South. Among diseases affecting fruits and fruit trees, the most notable example is the citrus canker, a disease recently introduced from Japan or Asia, and threatening the very existence of much of the enormous citrus development of Florida and the Gulf Coast, a disease which Congress has joined with the States in an active effort to exterminate with the aid of a large appropriation. In addition to these more important diseases, many minor plant diseases have also been introduced.

While, therefore, much of the original advantage which the western hemisphere enjoyed of freedom from plant pests has been lost, there are still vast numbers of foreign insect pests and plant diseases with large capacity for harm which have fortunately not yet effected suc-

*In view of the fact that fully 50 per cent of the tree and plant pests which in the past and at the present time are doing millions of dollars' damage every year to the agricultural and forest crops of the United States are imported, the American Forestry Association at its International Forestry Conference at Washington, D. C., January 18–19, 1917, heard addresses and discussions on the advisability of a national quarantine preventing the importation of tree and plant stock from other continents, unless such stock has the approval of the United States Department of Agriculture. This is one of the addresses, republished from *American Forestry*.

Cotton Boll Weevil (*Anthonomus Grandis*)

The cost to this country of the cotton boll weevil amounts to about twenty-five million dollars a year. It is gradually spreading throughout the cotton belt, and in 1916 reached northward to the South Carolina line. The picture, enlarged, shows an adult boll weevil.



Adult Male Hessian Fly (*Mayetiola Destructor*)

When excessively abundant this insect either destroys or badly injures hundreds of thousands of acres of wheat, reducing the yield from fifty to seventy-five per cent. This pest alone probably causes an annual loss in the United States of fifty millions of dollars.

Boll Weevil Larvae

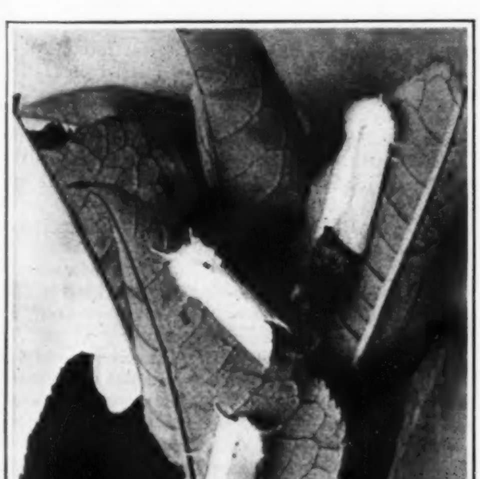
The manner in which the larvae of the boll weevil injures the cotton boll is indicated by this photograph. The ravages of this insect cost this country annually 25 cents apiece for every man, woman and child.

cessful lodgment in North America or have obtained only limited foothold and may still possibly be exterminated.

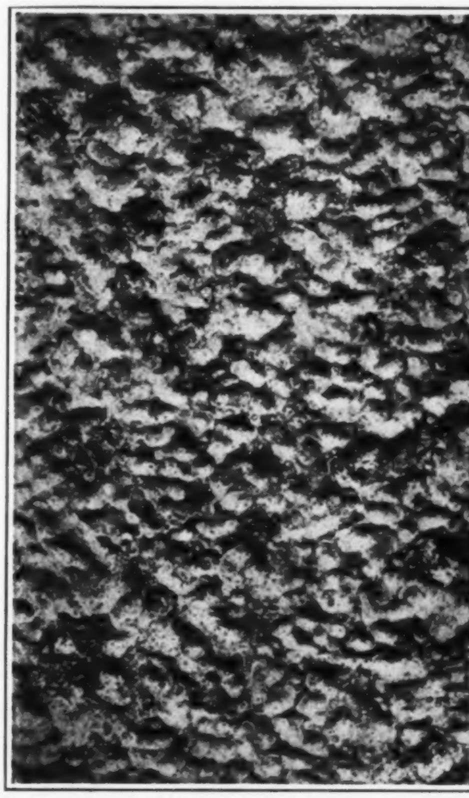
For the information of Federal and State inspectors the experts of the Department of Agriculture have prepared descriptive lists of the known plant enemies of the world, insect and fungous, which have not yet reached the United States or become permanently established therein. A manual describing the dangerous insects likely to be introduced into the United States, prepared in the Bureau of Entomology of the Department of Agriculture, and now in press, lists and describes over three thousand distinct insect pests. Probably half of these are old-world insects injurious to forest and shade trees, and the balance, insects injurious to various cultivated crops. A similar manual is in preparation on the funguos diseases of the plants likely to be introduced into the United States.

Among the important insect pests thus listed, which we hope to exclude from the American continent, are such notable examples as the Mediterranean fruit fly, perhaps the most destructive of all fruit pests; and the

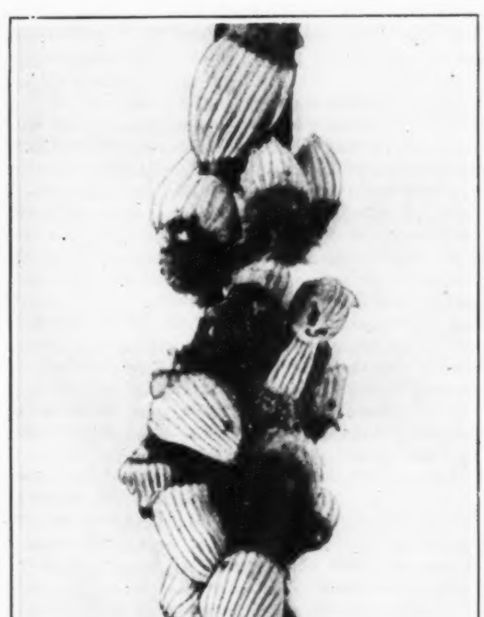
Stopping the Codling Moth
An apple tree banded in order to collect the larvae of the codling moth so that it may be destroyed.



The Brown-Tail Moth (*Euproctis Chrysorrhœa*)
The brown-tail moth was imported by a Boston florist about twenty-six years ago on roses from Holland and France. It is a serious enemy to the orchard, forest, and shade trees, and ornamental shrubbery, and has long been recognized as one of the worst orchard pests of Europe. The hairs on the caterpillars produce the brown-tail rash, often causing considerable annoyance to the residents of infested districts.



The San Jose or Chinese, Scale (*Aspditus Perniciosus*) **Enlarged**
Probably no other insect has received so much notoriety as this species. Its international importance is indicated by the vast amount of interstate and foreign legislation which has been enacted relative to it. Millions of dollars are expended annually in efforts to control this pest, which is so injurious to deciduous fruit trees.



The Fluted Scale (*Icerya Purchasi*) **Mask**
Introduced from Australia and at one time threatened the entire citrus industry of the Pacific Coast. Fortunately, through the introduction and establishment of its natural ladybird enemy, *Noeius cardinalis*, this pest is now under control, resulting in the annual saving of hundreds of thousands of dollars to the citrus growers.

pink boll worm of cotton, recently spreading from India to Egypt and thence to practically every other cotton-producing country of the world except the United States—an insect capable of doing vastly greater damage than the boll weevil. Among forestry insects occur such notable pests as the "nonne" moth of Europe, which is as destructive to conifers as the gypsy moth is in this country to deciduous trees; and many other forest caterpillars and bark-boring and wood-boring insects.

There are also known to occur in foreign countries many important diseases of plants which have not yet gained foothold on this continent. Prominent among these are the mildew diseases of the Indian corn occurring in the Orient; the potato wart, and many others affecting cultivated plants and forest trees.

The increasing commerce of the world with the hitherto little explored regions of China and other Asiatic countries and Africa, Oceania, etc., adds enormously to the risk of the importation of new pests. We know very little of the injurious insects of these new countries, but the importation of new stock in the last few years from these regions by the Department of Agriculture and by private agencies has especially demonstrated the existence therein of many very dangerous plant pests. The importance of these may be illustrated by referring again to some important pests now established in this country from these hitherto little explored regions of the old world. In this list comes the San José scale, the chestnut blight, citrus canker, and the corn mildews, introduced into some of our Southern States.

The more important of these known foreign pests are

An Important New Insect Enemy of the Peach (*Laspeyresia Molesta*)
Observations during the summer and fall of 1916 seem to indicate that another formidable insect enemy of the peach and other deciduous fruits has become established in America. Larvae of this insect have been observed injuring the twigs of peach, plum, cherry, and fruit of the peach. No. 1 shows a peach twig with a mass of dried gum and leaf fragments due to attack by the caterpillar. No. 2 shows a peach shoot cut open exposing the larva in its burrow. No. 3 shows the cavity excavated in the peach by larva entering at the side.

The Codling Moth (*Laspeyresia Pomonella*)
The codling moth, or apple worm, occasions a loss, in cost of spraying trees and injury to the fruit, of sixteen million dollars a year in the United States.

being excluded by regulating the entry of nursery stock, or, in the case of diseases, by an absolute prohibition of the entry of the plants or fruits affected. There are now in force nine foreign plant quarantines forbidding the entry into the United States of various plants and plant products to prevent the entry of new and dangerous pests. Two of these have relation to forest pests, namely the white pine blister rust and the European pine shoot moth. The others relate to the potato wart; the Mexican fruit fly; the pink boll worm of cotton; the avocado weevil; certain injurious insects and fungous diseases of the sugar cane; citrus canker and other dangerous citrus diseases; and the downy mildews and *Physoderma* diseases of Indian corn.

This Act also gives power of control within the United States of new and dangerous plant pests by quarantine or regulation of movement. This power, is however, now limited by the necessity of actually determining the presence of the insect or disease to be quarantined against in the State or district made subject to the quarantine. An enlargement of this power to be able to effectively quarantine against such a widespread disease as the white pine blister rust is now being sought.

The powers of this act in relation to the exclusion of foreign plant enemies has hitherto been directed towards specific dangers which could be shown by the Federal or State experts in relation to particular plants or plant products. In view of the tremendous losses which are now being occasioned by introduced plant pests and the additional losses which are now threatened by the many new plant pests likely at any time to be introduced, as herein shown, it is perhaps opportune now to seriously consider the advisibility of very much restricting the further entry of all foreign plants and plant products capable of being the agency of such introductions; in other words, to put all such introductions under definite Federal control and supervision, with power of exclusion wherever a reasonable risk is known. This need is emphasized just at this time by a number of important illustrations, already alluded to, of recently introduced pests, including the pine blister rust, chestnut blight, citrus canker, pink boll worm of cotton in Mexico, and a new peach pest from Asia, which has scarcely yet come to public knowledge, but which threatens our peach crop with greater losses than perhaps any of the older established peach pests. It would certainly appear that the enforcement of much more restrictive measures than are now possible is amply justified.

In this connection, and in relation to the natural desire to accumulate from the ends of the earth new field plants for our agriculture, and new fruits for our orchards, and the novelties and curiosities of the plant world for our gardens, lawns and parks, it must not be lost sight of that we have first to consider the safeguarding, that is, the conservation of the big commercial crops of America such as wheat, corn, cotton, potato, apple, peach, orange, etc., and our enormous natural forests which are and must always remain our chief productions. The risk to these standard products of our soil with all introductions of allied or varietal plants, and especially such plants from the hitherto little exploited portions of the earth, is enormous, as the illustrations already given have shown; and therefore all introductions should be preceded by studies and explorations to determine the risk, if any, in advance of the importation; and such importations should, furthermore, be surrounded with all restrictions and safeguards necessary to prevent the entry therewith of new plant enemies. In other words, the safeguarding of our big established productions should be the first and leading consideration.

Pests Detected Last Year

According to the report of the Federal Horticultural Board of the United States Department of Agriculture, one hundred and ninety-three different kinds of insects which might prove hurtful to American crops and one hundred and sixteen plant diseases of similar significance were detected by State and Federal inspection during the last fiscal year on plants and plant products offered for import into the United States.

Of the insects, fourteen were scale insects, such as Pear Scale, though they range from scales found on Orchids, Cocoanut, and Bamboo to other forms found on Wistaria, Camellias, Hemlocks and Pines. In addition, nests of the Brown-tail Moth, egg masses of the European Tussock Moth, pupae of the Dagger Moth, and cocoons of the Pine Sawfly were discovered.

Of interest was the finding of a fourth potato weevil in the United States, which was discovered in Irish potatoes imported from the Andes. Of the diseases, Citrus Canker was found in a number of shipments, and the finding of Powdery Scab on wild potatoes from the east slope of the Andes is taken to indicate clearly that it is the home of this disease of the potato.

Natural Measurement of Time—II.*

The Year and Its Limitations

By N. T. Dupuis

Concluded from Scientific American Supplement No. 2167, Page 19, July 14, 1917

THE CIVIL OR CALENDAR YEAR

As we have already seen, the tropical year does not consist of a whole number of days, and as far as we know the length of the year is incommensurable with that of the day.

But the calendar or civil year, or that year which is registered in the calendar and according to which all business and commercial matters are carried on, must begin with the beginning of a day and must consist of a whole number of days. For it would be very confusing—too much so to be permitted in practice—to have one year begin at 8 o'clock in the morning, say, and the following year begin at 1.30 in the afternoon, etc., and this is what would take place if we tried to measure the year in terms of its true length, and without any reference as to what time in the day it should begin or end.

It follows, then, that if the calendar year is to be kept from wandering too far from the tropical year the calendar years cannot be all of the same length, and that as we count the calendar years as each consisting of a whole number of days, some calendar years must differ from others by a whole day, at least.

How and when these changes or corrections are to be applied, so as to keep the calendar and the tropical years as near together as possible, is our problem.

The ancient Egyptians, from the very nature of their usage, in making one year end and another begin when the sun arrived at the summer solstice, and giving no special attention to the particular number of days in the year so determined, found no difficulty in keeping the calendar year and the tropical year near together, as the necessary lengthening or shortening of the year was automatically effected whenever required. But with all early people who endeavored to count their years solely as containing a certain number of days, there has been difficulty and sometimes confusion, arising principally from not knowing the exact length of the tropical year.

In counting their year by days, however, the Egyptians had a system quite peculiar to themselves. They knew that there were 365 whole days in a year, and so they established a year of 365 days. But, as we have seen, the tropical year consists of 365.2422 days, and .2422 is contained in 365.2422 about 1,508 times, so that the beginning, or the New Year's day, of this Egyptian year, occurring every 365 days, came in by about $5^h\ 49^m$ too early each year, and therefore ran through the whole range of the seasons in 1,508 years.

Instead of the number 1,508 the Egyptians adopted 1,460, which would seem to indicate that they assumed 365¼ days as the length of the tropical year. This term of 1,460 years was the *great* year, or the *Sothic* year, the latter name coming from the Egyptian term for the dog-star, or Sirius, which is the brightest fixed star in the heavens and which played an important part in the ancient system by its heliacal risings.

The Sothic year was a valuable arrangement for fixing dates, as two years having the same number in different Sothic years could not be less than 1,460 years apart, and therefore could not well be confused with one another. It is said that the Egyptians valued their calendar so highly that the priests exacted an oath from every new Pharaoh that he would not change the calendar.

Leaving the further consideration of this part of our subject until we come to the division of the year into months, we go on to investigate and see what is necessary to be done to keep the calendar year as near as possible to the tropical. For this purpose we may assume, at the beginning, that these years will never differ by more than a single day, for whenever this happens it would be corrected by adding on or dropping off a day, as the case may require.

The tropical year contains an excess of 0.2422 days over the calendar one, and whenever this excess accumulates so as to exceed one day, a day must be added to the calendar year. We must then divide 2,422 by 10,000, and find the convergents by the method of *continued fractions*.

A very close convergent is found to be 8/33, which means that the annual excess of .2422 days will amount to 8 days in 33 years; and we may now prove this by multiplying 0.2422 by 33. The result differs from 8 days by less than eleven minutes.

Now 33 being an inconvenient period, we may do as follows:

Multiply both 33 and 8 by 3 1/33 and we get 100, and 24 8/33 respectively. One hundred is certainly a convenient period, and 8/33 is nearly equal to ¼, so that we may take 100 and 24¼ for our numbers, and we find that the excess amounts approximately to 24¼ days in 100 years.

The calendar authorized by Julius Caesar, and known as the Julian calendar, adds on one day to every fourth year, counting from zero, and therefore adds on 25 days in 100 years; so that in this calendar every year evenly divisible by four is a leap year and contains 366 days, while every year not so divisible is a common year containing 365 days.

This arrangement is certainly very simple, but, as is readily seen from the foregoing calculations, it adds on three-fourths of a day too much in each century, or three days too much in 400 years. This excess, small as it is, amounts to 11 days in 1,500 years, and when uncorrected causes the equinox to travel backwards among the days of the month. Thus at the time of the Council of Nice in 325 A. D. the equinox fell upon the 21st of March, whereas by the year 1582 it had receded 11 days and had gone back to the 10th of March.

In order to prevent this wandering of the equinox, and to restore it to its former date, two things were necessary—first, to make such a correction in the Julian mode as to prevent the excess of 3 days in 400 years, and second, to drop out 11 days from the current count of time. These changes were decreed, upon the advice of astronomers, by Pope Gregory XIII, and the calendar so reformed is known as the Gregorian calendar.

In the year 1582 it was decreed that thereafter the full centuries—which according to the Julian calendar were leap years—should be leap years only when the century number is evenly divisible by 4. Thus 1600 was a leap year while 1700, 1800, 1900 were common years. This takes from the Julian count exactly 3 days in 400 years, as required for the correction of the calendar. And then to restore the date of the equinox it was decreed that the day following the fourth of October in that year should be counted as the 15th of October. This brought the equinox forward to the 20th of March, but it dropped out only 10 days instead of 11 days, as it should have done, so that the equinox now oscillates between the 20th and the 21st of March.

These changes came into force at once in all Roman Catholic countries, but they were not accepted in Great Britain until the year 1752, by which time the error had amounted to an additional day. In 1752 an act was passed by the British Parliament making the Gregorian calendar the legal one, and ordering that the day following the 2d of September in that year should be called the 14th of September, so as to bring the count into agreement with that of those countries which had already adopted the Gregorian calendar.

It will be remembered that the ratio upon which we have been working, that of 24¼ days in 100 years, is only a close approximation. To find its error and the means of correcting it, if necessary, we may do as follows:

Assuming the excess of the tropical year over 365 days to be 0.24224 days, as given in the best works on astronomy, we have the excess for 400 years as 96.896 days. But 400 years, by the Gregorian system, contains 97 leap years, and therefore accounts for 97 days. Hence the Gregorian calendar adds on too much by 0.104 days in 400 years, or 1.04 days in 4,000 years.

To correct this very small error it is proposed that the full thousands of years—which by the Gregorian system would all be leap years—should be counted as leap years only when the number of the thousand is not divisible evenly by 4. Thus, 2000, and 3000 will be leap years, but 4000 will not be.

The accuracy of the Gregorian calendar is wonderful when you consider that it was devised in the sixteenth century, and that by its usage the equinox would vary

*From *Queens Quarterly*.

from a fixed place in the year by only one day in four thousand years.

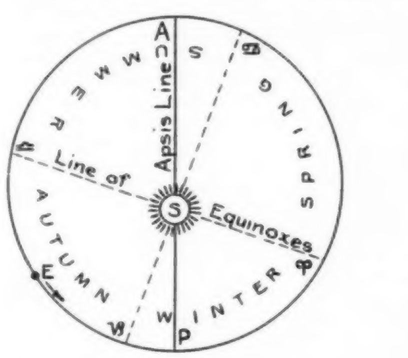
The proposed correction for a day in so long a period as 4,000 years need scarcely to be taken into consideration. For it is quite possible that changes in the rate of precession of the equinox during so long a term may require some other correction, if any, as it must be accepted that there is nothing fixed or invariable in the universe except its laws.

Before leaving this part of our subject it may be well to refer to the views of a writer who holds that the adoption of the Gregorian calendar was of doubtful advantage, because, according to his opinion, it would have been better to adhere to one fixed system which had been in use for nearly sixteen hundred years, than to change to a new system that would prove a stumbling block in the chronology of the future.

From this view we totally dissent. For we believe that it is immensely more important to man and his usages that the civic year be kept as close as possible to the equinoxes and the seasons, than that the equinox should be allowed to drift through the months to satisfy the requirements of an easy chronology. For we must remember that man lives in the present and has some interest in the near future, while the past, however valuable it may be as an index of the future, is forever fixed and out of our control. We may improve upon what is and what is to come but we cannot improve that which is past.

DIVISIONS OF THE YEAR

The seasons divide the year into four parts—spring, summer, autumn, and winter—but these parts are not



equal to one another. The reason of this will be readily seen from the accompanying diagram, which represents the earth's orbit with the sun at a focus. P denotes the perihelion point and PA the apsis line. The line of equinoxes is represented by ♎ ♈ and that of solstices by ♋ ♑. Then it is readily seen that the orbital distance from ♎ to ♈ is less than from ♈ around to ♎, distance being measured in the direction of the earth's motion as indicated by the arrow at E. Also the earth moves most rapidly in the vicinity of P, and most slowly in that of A, the aphelion point. So that, judging from this disposition of things, we would infer that summer is the longest season and that winter is the shortest, and that of the other two seasons, spring is longer than autumn. And from observation we obtain the following table which gives to the nearest hour the lengths of the different seasons:

		d	h
Vernal equinox to summer solstice	= spring	= 92	23
Summer solstice to autumnal equinox	= summer	= 93	13
Autumnal equinox to winter solstice	= autumn	= 89	16
Winter solstice to vernal equinox	= winter	= 89	1

This is for the northern hemisphere. For the southern one we would have to interchange summer and winter, and also spring and autumn.

These relations, like most astronomical ones, are subject to slow secular changes brought about mostly by the slow advance of the perihelion and the backward motion of the solstices. But many years will be required to produce any appreciable effect.

But there are, within the year, other well recognized groups of time periods, which have no necessary relation to the seasons or to the earth's motion in its orbit. The two most prominent of these are the week and the month.

THE WEEK

The week of seven days is the definite, accepted period of time next in length above that of the day. But while the day is characterized by distinct phenomena which limit its extent, the week has nothing of this kind which does not belong equally as well to a period of six or eight or any other small number of days. That is to say, that the day is an astronomical and a natural unit of time, while the week appears to be a purely artificial one, and yet the institution of the week goes back so far into the past that it is lost in dim and uncertain tradition.

What we wish to consider here is not only why a small and definite number of days were made to constitute a group, for that is evidently a convenient arrangement, but why the number of days chosen should be seven. Seven is not a convenient number, having no integral divisors, and being in every way the most intractable number below ten, besides seven is not a prominent or characteristic number in the general operations which naturally go on in this world.

The limbs of all mammals divide their extremities into five parts, or tend to do so, and nearly all phaenogamous plants built up their flowers on the scale of four or five or six, five being probably the most common. So that it does not seem that the institutors of the week drew the number seven from anything belonging to natural terrestrial affairs, and whatever it came from it must have been some phenomenon which excludes all possibility of arbitrariness.

That the number 7 was singularly prominent in the religio-astronomic thought of the ancients, is well attested by the stories and traditions that have come down to us. From the clay tablets resurrected from out the mounds which mark the sites of cities long passed away, we learn, among other things, that the ancient Babylonians and Sumerians numbered seven celstial genii and seven infernal genii; that there were seven storm demons which were overcome by the god Bel Merodach; that there were seven gates of hell; that a charm had to be repeated seven times to be efficacious, etc. And in the old Hebrew records we meet with seven years of plenty and seven years of famine; of Jericho being encircled seven times by the Israelites, of seven angels, etc.

The origin of the seven days in the week was, until comparatively recent times, not a matter for scientific investigation or even of legitimate speculation, but a matter of authority. The common and popular traditional authority is found in the Hebrew book of Genesis, second chapter and third verse, "And God blessed the seventh day and sanctified it: because that in it he had rested from all his work which God created and made." Here we have the Hebrew view of the origin of the week and of the sanctity of the Sabbath. But wherever this idea came from, it was not original with the Hebrew people, for we read from ancient clay tablets that long before Abram emigrated from Ur of the Chaldees to Canaan and there laid the foundation of the Hebrew race, the Babylonians had their Shabattu or Sabbath, being every seventh day set apart for the propitiation of the gods; and so strictly was it observed that even the king would not change his robes, or ride in his chariot, or sit in judgment, or officiate at sacrifices on that day. Thus the week and the Sabbath and the number seven, which occur so frequently in the Hebrew records, are not special Hebrew institutions, but belong to a much earlier civilization than that of the Hebrew people.

Then again, unless taken in some other sense than literally, it is difficult to see how the Hebrew theory of the week and the Sabbath can be acceptable to any one who is acquainted with the trend of modern thought, for the idea of the Deity tiring with six days' labor and resting on the seventh, can be described only as a remarkable piece of anthropomorphism, while the scientific view of creation is not that it is a something completed, but rather that it is a process which goes on continuously and forever.

But it is not alone the Hebrew or the Jew that is expected to acquiesce in these traditions and stories that grew up during the childhood of the race; the strictly orthodox Christian is in a position not one whit better. Christianity, at its inception, made the mistake of taking in and endorsing all the ancient Hebrew legends, under the theory that they were given by inspiration, and were therefore indisputably true, and that they were necessary to be accepted and believed in by all who expected to attain salvation. How such a comprehensive faith came to be adopted is not difficult to understand in the face of the fact that nearly all the world was at the time possessed of the geocentric idea.

But now that the whole civilized world rejects the geocentric theory, it becomes difficult to find any common ground for some of the pronouncements of orthodox Christianity and modern scientific claims.

All ancient people of which we have any definite knowledge, except perhaps a few of the later Greeks, were geocentrists. To them the earth was the center of the universe and the greatest of all material things, and sun, moon, and stars existed merely for the purpose of administering to this earth and the dwellers thereon. The earth was fixed and immovable, being supported upon some kind of a foundation, and the heavens with all that they contained revolved about the earth as a center. This idea of the fixity of the earth was common to all ancient people, and extended down into quite modern times, and no doubt a few people retain the idea even yet. Thus the writer of the book of Job makes the Lord say to Job: "where wert thou when I laid the foundations of the earth;" and as a convincing proof of the matter a middle-age theological savant argued that "as God is in the heavens and not in the earth, so God can move the heavens and not the earth."

These early people saw that the great mass of the stars remained at rest relatively to one another, but that a certain small number of heavenly bodies wandered slowly among the stars while pursuing each its own pathway about the earth; and all the cycles and epicycles of the Ptolemaic and contemporary astronomical systems were invented to explain the peculiar apparent motions of this small number of moving bodies. These bodies, taken in order of distance from the earth, and beginning with the most distant, are—Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon—seven in all. The planets here named can all be seen by the unaided eye, and they include all that can be so seen; and we have no reason for believing that anything like the modern telescope was known in ancient times. Also these are the only heavenly bodies—except an occasional comet which was always a vagrant and a harbinger of evil—that appear to move independently and on their own account.

Then again, we know that, besides some of the brighter stars such as Sirius, the sun, and the moon, and the morning and the evening stars were looked upon either as gods or the abodes of gods, and there is no doubt that all these strange self-moving bodies were regarded much in the same manner.

In the system of the ancient Babylonians, the whole day was divided into 24 hours, and over these hours these seven gods, as we shall call them, presided in orderly succession, while the day itself was sacred to the deity that came in with it. Writing these names in order, then—

Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon—and remembering that 7 divides into 24 with a remainder of three, we see that if Saturn presides over the first day, the Sun will preside over the second, the Moon over the third, Mars over the fourth, Mercury over the fifth and Jupiter over the sixth, as shown in the accompanying scheme:—

		English	*French*	
♄	Saturn's day	Saturday	Samedi	
☉	Sun's day	Sunday	Dimanche	
☾	Moon's day	Monday	Lundi	
♂	Mar's day	Tuesday	Mardi	Tiu
☿	Mercury's day	Wednesday	Mercredi	Woden
♃	Jupiter's day	Thursday	Jeudi	Thor
♀	Venus's day	Friday	Vendridi	Friga

in which the first column gives the astronomical symbol of the moving body; the second the corresponding day, of the day presided over by that particular deity; the third, the English name of the day; the fourth, the French name; and the fifth, some of the old Saxon deities corresponding to Roman ones, and which enter into the English names.

Saturn, the most distant of the known planets, was, for some reason, accredited with an evil influence, and the day sacred to it was, something like our Friday, thought to be unauspicious for the beginning of new undertakings—a day on which the gods were to be propitiated, and people were to abstain from the pursuit of their usual callings. This was the Shabattu of the Babylonians which subsequently became the Sabbath of the Jews.

The Christian, no doubt, partly through hatred of the Jew at the time, rejected the Jewish Sabbath and chose Sunday as his weekly holy day. But on what ground, other than that of common usage, he can claim for his particular day that peculiar sacredness that is usually ascribed to it, is a matter difficult to see.

As a remnant of old astrology the word *Saturnine*, which denotes a gloomy and morose disposition, was long believed to be applicable to, and distinctive of, a person born under the evil influence of Saturn.

We have now explained the origin of the week of seven days and the Sabbath according to the latest and most satisfactory knowledge on the subject, and along lines that are natural and reasonable. But arguments of this kind are lost upon those who prefer the explanation through ancient myths to that through natural phenomena.

At the time of the French Revolution, owing to the craze for working the number 10 into everything, an attempt was made to establish a week of ten days, but the authors of the ten-day week reckoned without their host. The influence of the church was against it and the people did not want it, and so it came to nought.

While we are not in sympathy with the argument that on account of its divine origin, the week of 7 days is absolutely perfect—an argument which has sometimes been put forward—we nevertheless believe that a week of 7 days is better, in several ways and for several reasons, than one of 10 days would be.

Sighting Telescopes for Fire-Arms*

Instruments that Aid in Precision in Long Distance Shooting

By Ernest Coustet

It would have been useless to increase the range of fire-arms if at the same time the sighting-apparatus had not been perfected. The effectiveness of the fire, is, in fact, limited by the eye's faculty of accommodation, by the separating power of the retina, and by the parallax effects resulting from insufficiently exact pointing.

In the ordinary process of taking aim, the eye is obliged to fix at one and the same time, the sighting notch, the front-sight, and the target. But it is absolutely impossible to see simultaneously three objects, at such different distances, with precision; it is necessary to accommodate the vision to these three distances one after the other, thus imposing upon the eye a fatiguing amount of gymnastics. Moreover, the slightest displacement of the pupil with respect to the sighting notch causes a deviation in the aim and throws the projectile correspondingly wide of the target. Likewise, even a slight weakness of vision causes incapacity for taking aim beyond a certain range.

Gunsmiths have thus been led to adapt, first to big guns, and then to side-arms, sighting telescopes analogous to those employed in geodetic operations. These telescopes offer several advantages: they permit the most near-sighted gunners to perceive distant targets with precision, and above all they assure great exactness of aim at distant targets, while preventing eye fatigue.

The aim in the telescope is effected simply by gazing at a reticule placed at the focus of the objective. This reticule is usually composed of two delicate threads stretched across each other in the form of a cross, and precision of aim is secured merely by bringing the image of the target directly over the crossing point of the threads. The adjustment of the ocular, moreover, brings the image of the target to the focus, *i. e.*, it is found upon the same plane as the reticule, so that the eye is no longer required to modify its accommodation.

The elevation of an ordinary rear sight can be replaced by vertical displacement of the reticule. However, this arrangement, which is sufficient for side-arms, is not suitable for the great distances now attained by artillery. It often happens that the object aimed at is difficultly visible, or even completely masked by an obstacle, a forest, a hill, etc. Moreover, the wind causes the projectile to swerve from its path, so that it is necessary to aim in a direction more or less divergent from the target. Hence it is customary to sight, not the target itself, but some nearer object, whose line of direction makes with that of the target an angle previously determined upon. It follows that the sighting telescope must be capable of movement independent of the gun, so that the angle formed between the direction of the optical axis and that of the fire-arm may be measured with great precision. These conditions are now realized with great exactitude. We are indebted to Messrs. Schneider & Co. for the two photographs (Fig. 1), representing the sighting apparatus of a mortar. The essential organ, the binder, is a panoramic telescope whose arrangement is shown in Fig. 2. The ocular is fixed, as is also the lower prism, but the upper prism is capable of describing a complete revolution around a vertical axis. The image is sighted by a tetrahedral prism, mounted on a planetary gear which causes it to revolve in the opposite direction and with an angle only half as large as the displacements of the upper prism. This combination is necessary to maintain the images of objects in the erect position.

The axis around which the rotation takes place must be strictly vertical. But on the ground the wheels and the trail-spade of the gun are rarely placed on a horizontal plane. This is why the sighting apparatus is mounted at the left of the piece of ordnance, upon a jointed support connected with the pointing sector. It is provided with spirit levels and with goniometers graduated in *thousandths*.

The *thousandth*, a new unit of angles adopted by the French artillery equals 3′ 26″. Its practical importance comes from the fact that it represents the angle which includes an object of one meter at a distance of one kilometer.

*From *La Nature* (Paris).

The enlargement due to the telescope is four times, and its actual field 10 degrees. The reticule is engraved upon a sheet of glass placed at the focus of the ocular and lit by a lateral window of red glass.

At one side of the upper prism is a finder consisting of a tube bearing a reticule and a sighting window. The

Fig. 1. The Schneider panoramic telescope

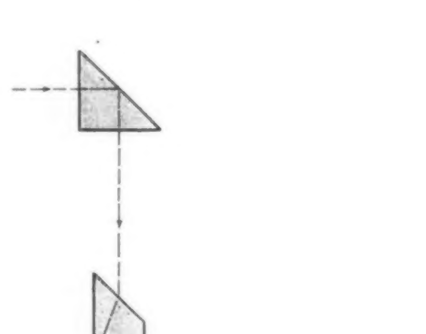


Fig. 2. Optical arrangement of the Schneider telescope

Fig. 5. Reticule for estimating distances

finder, like the prism, is movable, not only around the vertical axis of which we have already spoken, but also around a horizontal axis, carrying with it in its movement the oscillation of the prism. This double movement, measured by the goniometers, permits the choice of a *datum* in any azimuth whatever and in a position comprised between 0 and ±300 thousandths.

The telescopes intended for side-arms must satisfy other requirements. They must be light and as little of an encumbrance as possible. It is requisite, also, that they should afford a rather extended field, for they serve also as finders, and that the objective should be luminous enough to facilitate firing in dull weather, at twilight, or in the woods; finally, it is indispensable that the eye of the marksman should be far enough from the ocular not to be wounded by the effect of the recoil.

Galileo's telescope is not applicable here although it is the simplest and shortest of such instruments, its length being equal to the difference between the focal distances of the objective (converging lens), and the ocular (diverging glass); moreover its field is very restricted and the observer is obliged to put his eye very close to the ocular; then it is not possible to mount a reticule within it, since no real image is formed, but only the virtual image.

The astronomical telescope is no more complicated, since it comprises only the objective and the ocular, both formed by convergent systems; it is longer than the preceding, but, since it forms a real image, a reticule can be arranged at the focus of the objective; unfortunately, though, this image is reversed. This is not a serious inconvenience in the observation of stars, but in order to aim without hesitation at an object which changes its place more or less rapidly, it is necessary to see it in its true position, and to follow its movements in their correct direction.

The reversing of the image can be accomplished by the aid of a converging lens, inserted between the objective and the ocular. It is upon this principle that field-glasses are constructed. In practice a fourth lens is added, the *collector*, which increases both the enlargement and the amplitude of the field.

Fig. 3 shows the arrangement of this instrument: 1 is the objective, 2 the collecting lens, 3 the reversing system, 4 the ocular, 5 the reticule, and 6 the mechanism which governs the vertical displacement of the reticule diaphragm. This displacement is effected by the aid of a micrometric screw whose head expands, on the exterior, into a drum on which the graduated distances can be read.

Various forms are given to the reticule. Fig. 4 shows the ones most used, and Fig. 5 shows a model which permits an estimation of the distance of the target, when its dimensions are approximately known. In fact, the length of each of the three delicate threads (Fig. 5), starting from the center, is so regulated as to cover, upon the image of the target, a width equal to one-fiftieth of its distance. Some telescopes are delivered with several interchangeable reticules, and these reticules are sometimes all contained in the mounting of the instrument and can be made to appear at will, by hinging to the focus of the objective the one desired.

Like all these telescopes, this one is regulated to fit the eyes of the marksman, by drawing out the tube which carries the ocular, or pushing it in. The ocular is 8 centimeters distant from the eye, so as to avoid all danger of injury from the recoil.

However, the field glass is not without its inconveniences. In the first place the field is still comparatively restricted, in spite of the aid of the collecting glass; then the dimensions of the mount become rather cumbrous as soon as the enlargement exceeds three or four diameters. In order to protect the eye of the marksman from the shock of the recoil oculars of long focus must be employed, and in such conditions sufficiently large images cannot be obtained except by adopting a long focus for the objective also.

Opticians have therefore been obliged to seek for another method of reversing the image of the astronomical telescope, and they have found it in the employment of reversing prisms, already used with so much success for opera glasses.

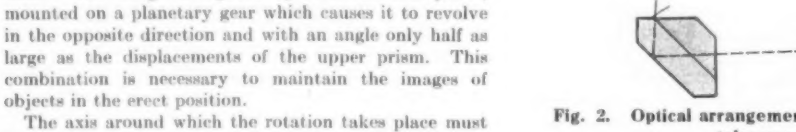


Fig. 3. Section of field-glass finder

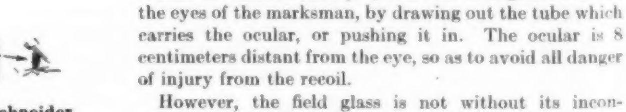


Fig. 4. Principal arrangements given to the reticule

They first intercalated a double prism between two convergent systems, as shown in Fig. 6. Here 1 is the objective, 2 and 3 the prisms, 4 the ocular, and 5 the reticule, whose axis is displaced in the vertical direction, according to the distance of the target, by means of a screw with a milled head arranged behind the prisms.

This combination has been rendered simpler and lighter by the suppression of one of the prisms. Fig. 7 gives a diagram of the telescope with a single tetrahedral prism, and the following illustration (Fig. 8), shows its external aspect, as well as its method of attachment to the Mauser rifle. This finder is characterized by its very reduced dimensions and by the amplitude of its visual field, 13½ degrees. In spite of this wide angle there is no danger that the forward extremity of the barrel will conceal a part of the image, for the objective is placed very considerably higher than the ocular. The clearness of the instrument is such that it permits aiming with certainty even when the twilight has become quite dull. The ocular can be regulated as usual to the eye of the marksman and can be firmly fixed after such adjustment, so as to run no risk of displacement by the shocks of a prolonged period of firing.

The adjustment of the reticule according to the firing range is effected by the aid of a milled ring which surrounds the objective. Another ring serves to lock the regulating mechanism. A rubber hood is adapted to the ocular in cases where the aim would be disturbed by the surrounding light.

The method by which this telescope is mounted permits it to be quickly removed from the gun; moreover, it is easy to arrange below the instrument an opening for ordinary sighting.

The enlargement of the objects (generally comprised between two and one-half and five diameters) and their apparent nearness, realized by this optical combination, permits the easier discovery of the enemy, and the following of his slightest movements. The simultaneous vision of the target and of the cross-hairs, whose images are brought by the lens to the same plane, enables the eye to avoid all fatigue of accommodation, and the precision of the pointing renders the most mediocre marksman redoubtable.

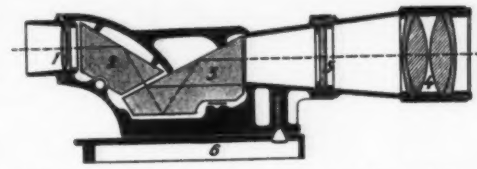


Fig. 6. Cut of telescope with two correcting prisms

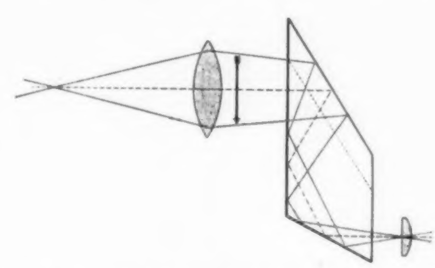


Fig. 7. Diagram of the tetrahedral prism telescope

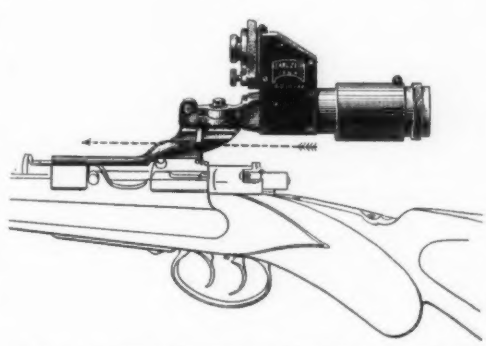


Fig. 8. Prism telescope on a Mauser repeating rifle

Nevertheless, when taking aim in this way at great distances, the target will not certainly be hit if one confines himself to merely raising the rifle to the shoulder. It is never possible, in fact, to avoid little motions of the arms and a slight trembling of the hands. These displacements, which are imperceptible and unimportant when firing at short distances with the primitive method of taking aim, betray themselves, on the contrary, by marked displacements, when it is an affair of distant targets; and telescopic observation, moreover, permits one to take note of the fact that the image of the object aimed at departs momentarily from the optical axis. Precision of aim, therefore, cannot be assured except by placing the fire-arm on a rigid support. The result is that the telescope gun has been particularly employed at the posts of sharp shooters in the trenches, where its position was previously indicated.

The arm, solidly supported, permits the certain hitting of anything abnormal in the field of vision, and it is by this means that since the beginning of the war the Germans have made a sport of hitting at long distance anything that seemed to indicate the chief member of a group. Naturally the soldiers to whom this duty has been confided, must serve in their turn as excellent targets, and an endeavor must be made to protect them. For this purpose the sighting telescope has been combined with the polemoscope. These have been found, in the German trenches conquered by our troops, rifles provided with a counter stock and a set of mirrors. The arm placed upon the parapet can thus be maneuvered from below while the marksman remains under shelter. As for ourselves, it is no secret that long before the war our gunsmiths had already applied telescope finders, not only to the Lebel rifle, but also to rifles designed for hunting big game. And that every improvement of processes of attack makes the strongest of appeals for improvement of means of defense, and in this point the facts of war do but confirm a general law of the struggle for existence: the instinct of conservation always triumphs in the end over means of destruction.

Eliminating Blue Monday from the Navy*

A few years ago the martial atmosphere of Uncle Sam's men-o'-war used to be considerably impaired when Monday put in its appearance. For, in the olden days of the service, the first day of the week was just as repugnant to the men of the country's first line of defense as it was to the average housewife. Monday meant wash-day in the navy the same as it did ashore. In more ways than one it was a day to be dreaded.

Moreover, wash-day was a bit tougher on Jack afloat than on Mrs. Housewife ashore, if anything. In the latter case, if she did not care to wear herself out over the wash-tub, she could send her week's supply of soiled linen to the nearest laundry and forget about it. Or, if she did choose to do her own laundry work, she could at least put it where it would not drip water all over her, by using a clothesline in the yard or on the roof. But not so a naval fighting man.

Washing linen in the navy under the old regime not only meant flooding the ship from one end to the other, so to speak, but it also entailed the hardest kind of labor. The sailors did not have the convenience of wash-tubs. They had to spread the garments out on the upper deck and slosh them over with water, which was carried off through the port and starboard scuppers; then, after coating the pieces with a lather of soap, the sailors took a good stiff scrubbing brush in both hands, got down on their knees and applied "elbow grease" in a most vigorous manner. This form of muscle-washing undoubtedly was a good dirt-chaser, and, by the same token, it was a splendid way in which to wear out garments.

The second disagreeable phase of the old-fashioned navy wash-day was to be found in the hanging-out-to-dry process. It was in this respect that the housewife had an advantage over the sailor. When he hung up his garments to dry the only clotheslines available were the halyards attached to the masts, which meant that when "all hands" had hung up their wash it would be waving directly above the deck. This not only made the deck a disagreeable place to lounge, owing to the rivulets dripping down from above, but it also gave the battleship a most ludicrous appearance. At such times the fighting craft of the navy looked more like barks intended for some musical comedy than potent defenders of American honor. But that has all been done away with.

The modern American navy is the embodiment of preparedness, from stem to stern, from keel to crow's nest. It is prepared to meet the foe from either a martial or sanitary angle. All first line ships, such as the U. S. S. "Pennsylvania," the laundry of which is about to be described, are equipped with the last word in laundry machinery. The small yet highly efficient laundry of this superdreadnought handles the linen of approximately 1,200 officers and men every week. The plant of the "Pennsylvania" is confined to about sixteen by fifty feet of space, which is pretty small for a laundry. Space is at a premium on a battleship, because most of the room must be available for fighting purposes.

The equipment consists of fourteen pieces composed of the following units: One rectangular disinfector, two washers, two extractors, one ninety-gallon soap tank, a two-compartment wood tub, one ten-gallon copper starch kettle, a drying tumbler, one two-loop metal conveyor dry-room, one body ironer, a single roll flat work ironer, one band ironer, and a collar shaper. All of the equipment is motor driven.

The method of handling the work in the "Pennsylvania's" laundry differs little from that found in its bigger prototypes ashore. A systematized method of collecting and delivery service is maintained. In order to avoid a great congestion of work, each member of the crew is assigned a day on which to have his laundry taken care of. The members of the crew are assessed a flat sum of 50 cents a month for this work, which amount covers as much or as little as he may send in. The work of the officers is handled somewhat differently, as they are charged at the rate of 2 cents per article. This charge covers any article sent in, and when it is considered that some of the table cloths used on the tables in the officers' mess are 60 feet in length the liberality of the charge is evident.

After the goods have been received in the laundry they are assorted and marked in the receiving room and the regular washing process is followed. All goods which are "tumbled," such as bath towels, flannel shirts, blue uniforms, etc., are not pressed, but neatly folded and sent directly to the delivery room, where they are again assorted and placed ready for delivery.

An idea of the efficiency of this little naval plant can be gained from the fact that an average of 3,500 pieces of all kinds of work is handled per day. In a week's time about 500 shirts and about 1,500 collars pass through the plant. Furthermore, the most astonishing part of it all is that the force which handles this volume of work is only three men! The receipts from the laundry total about $800 per month. Considering the many difficulties encountered in handling work on shipboard, the goods turned out by the laundry compares very favorably with that turned out by the average laundry on land, it is said.

*From an article by "Knicker Bocker," in the *National Laundry Journal*.

Science Not Responsible for War

A few days ago a correspondent of the *Daily Mail* resuscitated a well-known quotation from George Gissing's "Private Papers of Henry Ryecroft," in order to associate science with the horrors of the present war. The words are as follows: "I hate and fear 'science' because of my conviction that, for long to come, if not for ever, it will be the remorseless enemy of mankind. I see it destroying all simplicity and gentleness of life, all the beauty of the world; I see it restoring barbarism under the mask of civilization; I see it darkening men's minds and hardening their hearts; I see it bringing a time of vast conflicts, which will pale into insignificance 'the thousand wars of old,' and, as likely as not, will whelm all the laborious advances of mankind in blood-drenched chaos." We have on several occasions pointed out that it is merely pandering to popular prejudice to make science responsible for German barbarity or for the use of its discoveries in destructive warfare. Chlorine was used as a bleaching agent for much more than a century before the Germans first employed it as a poison gas; chloroform is a daily blessing to suffering humanity, but it is also used for criminal purposes; potassium cyanide may be used as a poison or to extract precious metals from their ores; and so with other scientific knowledge—it can be made a blessing or a means of debasement. The terrible sacrifice of human life which we are now witnessing is a consequence of the fact that the teaching of moral responsibility has not kept pace with the progress of science. As in medieval times all new knowledge was regarded as of diabolic origin, so even now the popular mind is ever ready to accept such views of the influence of science as are expressed in Gissing's work. The pity of it is that the public press does nothing to dispel illusions of this kind by urging that what is wanted is not less scientific knowledge, but a higher sense of human responsibility in the use of the forces discovered.—From *Nature*.

Economizing Coal in Gas Making

At a large gas plant in Holland the experiment has been made of mixing peat and the coal with excellent results. The quality of the gas is satisfactory, and a considerable saving of coal is effected. The charge for the retorts is made up of two parts by weight of coal and one of peat; the peat is entirely consumed, so there are no by-products. It was found that if peat alone was used the retorts became over-heated, because of the steam resulting from the moisture that is always present in peat.

The Meaning of Bird Music*

Songs of Whose Beauty the Birds Are Consciously Appreciative

By Henry Oldys

When on some dark, overcast night in late September, there comes to the ear from overhead sundry piping or chirping notes, it is easy to recognize them as auditory signals holding together certain flocks of migrating birds on their annual journey to the South. But when one of these migrants, while returning to its summer home, perches on a twig and, with head thrown back and throat vibrating, pours out a series of orderly tones, the significance of the utterance is not so apparent.

It is now the well-settled opinion that such utterances do not find their primary stimulus in courtship and mating. Darwin's theory that the choice of mate on the part of the female is an important factor in development of song in the male, has been sufficiently discredited by Herbert Spencer, St. George Mivart, August Weismann, and others, and is now discarded by virtually all the leading students of evolution. It is, of course, undeniable that songs, like plumage displays, are used in connection with courtship; but such use is merely an incidental one, as it is with human beings, and is probably seldom, if ever, the determining factor in the female's choice of a mate. Moreover, even on Darwin's assumption that the finest singers mate most easily and so transmit their superior qualities by inheritance more frequently than singers of a lower grade, thus gradually improving the race musically, it is doubtful if such progenial transmission of musical qualities would prove to be the chief means of progress, in view of the important part played by acquisition of song by imitation in musical improvement among birds. It is well known that the singing powers of canaries are not produced by breeding from gifted ancestors, but by associating the birds with unrelated superior singers known as "campaninis," which are kept for this special purpose and which often command very high prices. Wild birds similarly improve their singing by imitation of better singers of their own species, as is evidenced by several direct examples of such imitation which have come to my personal attention. Furthermore, few female birds sing; and it seems most probable that if they possessed sufficiently discriminative ears to appreciate and select the finest singers among the males, they would themselves become singers.

But if Darwin's theory of sexual selection be inadequate to account for the development of bird song from the original unmusical ejaculations to the present melodies, what is the true cause of such development? The simple and natural answer is that musical evolution among birds is due to the same causes that have produced musical evolution in man, especially as the results of the two streams of evolution show marked resemblances.

It is customary, at the present time, to deprecate any interpretation of animal behavior in terms of human behavior—to attempt to explain all actions of the lower animals on the basis of different psychical processes from those producing similar actions on the part of the human species. This attitude expresses the natural reaction against the popular tendency to overhumanize the lower animals. Unscientific minds assume for the behavior for all animate beings the same mental causes that would produce such behavior in themselves; but scientific minds, in combating this error, transgress equally in the opposite direction. Such reactions generally go too far. Thus the constant use of consecutive fifths and octaves for several centuries in the earlier stages of our modern music has led to a rabid proscription of such harmonic progressions; and a later overindulgence in the chord of the diminished seventh has brought that attractive and serviceable combination of tones into almost equal disrepute. Hence, the complete humanizing of the animal world by ignorance has led to the complete dehumanizing of it by learning. It is the reverse swing of the pendulum.

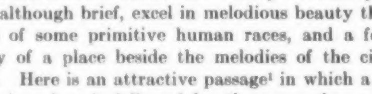
Disregarding the many physiological likenesses between ourselves and these fellow creatures of a lower evolutionary stage, science emphasizes the physiological differences and makes them the basis for an almost totally different psychological method of arriving at results. Yet, as in the human mind, instinct mingles with reason, so in the animal mind reason mingles with instinct. When we are confronted with two musical evolutions paralleling each other remarkably, the most rational supposition is that such evolutions are alike in their origin and in their sustaining causes. The birds display evidence of enjoyment of their songs; they manifest a proneness to sing freely when happy and to be mute when unhappy; they show a seeming interest in the performances of more accomplished singers, and an apparent desire to acquire phrases and tones that excel their own; they exhibit much knowledge of the value of rhythm, of melody, of tonality, and even of sequence of related musical phrases; in all these things paralleling ourselves. An explanation of these attributes on any basis but that of musical appreciation (by which human attributes of the same kind are explained) would be most complicated, far-fetched, and altogether unsatisfactory. The rule adopted by investigators of the psychology of the lower animals is never to accept an explanation based on higher psychical processes when one based on lower psychical processes may be made. A useful rule; but it is easily metamorphosed into a rule never to accept a simple, direct explanation when a more complicated, indirect one may be assumed. And many of the interpretations of psychologists seem to be governed by this derived (and pernicious) rule.

As with man, so with birds, the development of musical appreciation ranges from zero to the maximum. While the impulse to express emotion vocally is common to many creatures, such expression in musical form is limited to comparatively few. The dog barks his joy, the bull roars his definace, the cat purrs her content, the hog grunts its satisfaction, but utterances of this character can by no legitimate stretching of the term be described as music. So, too, among birds the rattle of a kingfisher, the scream of an eagle, the squawk of a parrot, cannot be classed as musical performances. Nor is there any physiological line of demarcation between musical and non-musical birds. The crow and grackle, although properly classed structurally with the *Oscines*, or singing birds, are lacking in musical expression; while the wood pewee, dove, bobwhite, and others beyond the pale physiologically, express themselves musically, the wood pewee taking high rank in this regard.

Even the common barnyard cock will occasionally express his exuberant feelings in true melody, as in this paen with which I heard a Maryland cock greet the dawn on a November morning:

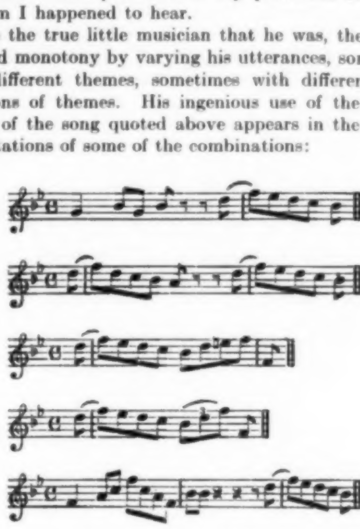
and in which the final descent of the gamut was accomplished by distinct steps, unblurred by any *portamento*, or slur, and in good strict time. Many of the *Oscines* that may properly be classed as melodists hold their title by a very slight grip. The lisping or buzzing songs of most species of warblers, the incoherent utterances of purple finch, goldfinch, warbling viero, junco, and like singers, the twittering chirpings of swallows, the monotones of nuthatch and chipping sparrow, and the indeterminate notes of house wren, indigo bird, and English sparrow (in his rare musical moods)—these performances, although often pleasing to the ear, are almost entirely lacking in melody, as known and enjoyed by man, while the dickcissel expresses his emotions in articulations that seem to belong to speech, rather than song.

On the other hand, some of the avian melodists are entitled to high rank as musicians, even when judged by human musical standards. Many of their productions, although brief, excel in melodious beauty the best efforts of some primitive human races, and a few are worthy of a place beside the melodies of the civilized world. Here is an attractive passage[1] in which a theme in a minor key is followed by the same theme in the relative major key, with a change from *piano* to *forte* that gives a distinct touch of brilliancy:

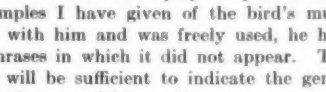


This is not, as might be thought, an extract from the note book of Mozart, Bach, or Mendelssohn, but an excerpt from the song of a rock thrush (*Monticola saxicola*) I heard in the Worthington Aviary at Shawnee-on-Delaware, Pennsylvania, four or five years ago. The notes were perfectly true to pitch and were given in a quality of tone that was exactly that of the human whistle. The attendants at the aviary had picked up the bird's phrases, and during my three days there I could never tell without inquiry whether the bird or an attendant was responsible for any particular rendering of them I happened to hear.

Like the true little musician that he was, the thrush avoided monotony by varying his utterances, sometimes with different themes, sometimes with different combinations of themes. His ingenious use of the second theme of the song quoted above appears in the following notations of some of the combinations:

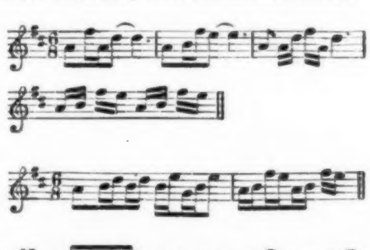


But while the theme that plays so prominent a part in the examples I have given of the bird's music was a favorite with him and was freely used, he had several other phrases in which it did not appear. The following one will be sufficient to indicate the general character of the rest of his music:



It will be apparent to any musician, of however humble rank, that the music here written (and it is an exact transcription of the notes sung by the bird) is perfectly comparable to our own music of this twentieth century; and not only in the use of the same scale, but in rhythm, melodiousness, and harmonious balancing of phrases. Careful examination will disclose several effective touches, such as the use, in one of the combinations given above, of the E♮ before the following F's.

The rock thrush is found in southern Europe, and, if I may safely judge from my own experience with this one individual bird and from the rank accorded the species by some observers of it in its wild state, I should say that it is of all European birds the most melodious —using the term in its proper sense and not in the loose way in which it is generally handled by a careless public. Its chief rival seems to be the European blackbird (*Merula merula*). Personally I have little knowledge of the singing of the blackbird, although I have noted one or two utterances from some in American zoölogical collections that indicated the high musical character of the bird in its native wilds. I am able, however, to reproduce three blackbird songs of a very choice quality musically, which were recorded at Sèrvres, France, a few years ago by an accomplished musician and lecturer on music, Mrs. Amelia von Ende:



These three songs disclose a strong feeling for harmony as well as for melody. The alternation of tonic and dominant harmony in the first is very effective, while the pleasant modulation to E minor in the second is quite satisfying. Particular praise must, however, be accorded to the third song, which presents an attractive, sprightly, and well-developed theme.

But it is not necessary to cross the ocean to obtain examples of good music from birds; our own land is the home of some of the best of avian musicians. I have secured several four-phrase songs from our own thrushes

*From the *American Museum Journal*, published by the American Museum of Natural History, New York.

[1]Although the fact is unimportant, it may be stated that all the bird songs given in this article were sung an octave higher than they are here written.

which in beauty of melody and arrangement of themes surpass all other avian music that has come to my attention, and we have other species that take high musical rank. The song sparrows furnish melodies enough to equip nearly every member of the woodland chorus with a different song for each. Some of these song-sparrow themes are very satisfying. Here is one I heard in northern Ohio last spring:

This, although simple, is a very pleasing and melodious phrase, one that no human musician need be ashamed to borrow for incorporation into some more elaborate composition of his own. And let me say here that our woods and fields are full of suggestive themes for the enterprising musician who awakens to the fact that man has no monopoly of melody. One, at least, of the fraternity recently had his eyes opened to this wealth of musical material, and the result of his discovery is a book of songs about birds in which the melody of each song is made up of themes furnished by the bird to which it relates. Some of these songs are very beautiful.

More remarkable than the union of related phrases in sequence by one bird are those performances, occasionally to be met with, in which two related phrases are sung antiphonally by two separate birds. The meadow larks of the eastern half of the United States (*Sturnella magna*) are especially prone to sing duets of this kind. From forty or more such meadow lark duets that I have noted I here reproduce one sung by two birds on my own place last March:

Were the first bird saying, "I love to sing," and the second rejoining, "So I perceive," the effect of phrase and answer would not be more marked.

From such examples of bird music what are we to conclude as to the meaning of bird song? We find some of the birds uttering musical phrases and sequences of phrases that are governed in their construction by rules that govern the construction of our own musical compositions—that conform to those constructive principles that are developed by musical taste in man. Melody, rhythm, harmony, and tonality combine to make them pleasing to our ears in precisely the same way that human music appeals to us. To account for this phenomenon by a theory of chance coincidence requires a degree of credulity that is immense. That a bird should so combine notes as to produce human music accidentally is as incredible as that it should so combine articulate sounds as to form human speech accidentally. To assume that birds are the unconscious instruments of a higher power made to produce such performances as man alone can appreciate and enjoy, is to return to the long-abandoned attitude under which the stars were regarded as mere points of light, created for the purpose of relieving man of absolute darkness on moonless nights. There remains only the idea that birds sing songs of whose musical beauty they are consciously appreciative. This is the simplest and most plausible interpretation of the matter; and if we are brave enough to disregard that bugbear of the average psychologist, anthropomorphism, we shall understand that birds share with man an intelligent appreciation of music, the difference being one of degree, not of kind. We may not comprehend the full philosophical significance of our own musical emotion, but we may safely rest in the assumption that whatever light we have in this respect equally illumines and makes plain the meaning of bird song.

Artificial Eyes*

Their Early History and Modern Improvement

By Dr. Mary Davro

From the ninth and eight century B. C. the Egyptians were in the habit of investing their mummies in cases or cartons which formed a sort of armor for the defunct person, and were composed of several pieces: a "boot" into which the feet were inserted, a painted and carved casing for the chest, and over the face a mask representing the features of the deceased, with his blue or black ceremonial wig. Specimens of these masks are to be found in various museums. They are composed of several thicknesses of fine cloth pasted together, pressed in a mold, and covered with a layer of stucco or plaster fashioned by the artist into a likeness of the dead person

Dr. Coulomb has in his collection a beautiful funeral mask of this sort, dating from the first century of the Christian era and furnished with very pretty *artificial eyes*. The sculptors of ancient times, too, adorned their statues with materials more or less rare, such as wood, marble, ivory, lapis-lazuli, and so forth.

At first the Egyptian embalmers enucleated the eyes of corpses and then poured plaster or white wax into the orbits in order to inset a precious stone, such as obsidian, for example. Then later they substituted for the wax or plaster shells of silver or other metal, sometimes enameled in white and perforated in the center with a hole representing the pupil. But neither the Egyptian embalmers nor the Greek and Roman sculptors ever provided the living with an artificial device to take the place of a lost visual organ. The first authentic test which mentions the *prothetic eye* is the passage in the Talmud when it is related that Raffi Ismael had made for a young girl an eye and a tooth of gold in order to embellish her. No other information upon this subject has been discovered either in the Middle Ages or the Renaissance. But artificial eyes of enameled gold are described and pictured in the works of Ambroise Paré. These, which were not very widely used, were then made by jewelers; and in case one of these could not be lodged in the orbit, he even recommended another apparatus "made of iron wire flattened, bent, and covered with velvet or taffetas, having one side flat that it may not wound, and the other covered with wrought leather, to which the painter gives by his artifice the image of an eye. When this is done it is placed over the orbit. But the said wire can be extended and bent like those which are used to wear to hold their hair in place. It will pass above the ear around half of the head."

In 1601 a Hungarian doctor, Jessenius, speaks in his *Surgical Institutions* of a Florentine jeweler who manufactured, at Venice, artificial eyes of glass and sold them for as much as 6 or 7 crowns. In an extent specimen, made in Venice, and dating from 1580, the sclerotic is white, the iris brown, and the pupil black, but the ensemble does not give a very good illusion of the anterior chamber of the natural eye. The shell of glass, which is painted on the concave side, this being then covered by a thin plate of polished lead, seems to have been fashioned upon a grindstone. The lead covering had the double purpose of preventing irritation of the "stump" and of preventing the tears from dissolving the colors.

Later, from the middle of the seventeenth century, the art of the ocularist doubtless declined at Venice, since we find that the heterophthalmic of two worlds provided themselves almost exclusively in France, and especially at Paris, with the crystal eyes which were sold on the Pont Neuf as early as 1682. History, moreover, has preserved for us the name of some of the most celebrated French specialists of the epoch; among others the Parisian Hubin or Hubins, of the "Rue Saint-Denys, opposite the Rue aux Ours," his competitor, the sieur Le Quin, established in the Rue Dauphine, and a remarkable artist who exercised his profession at Nevers towards the middle of the eighteenth century, and to whom some authors ascribe (wrongly, however) the invention of the eye made of glass. The fame of certain ocularists of the French capital even extended beyond our frontiers, as is testified to in a memoir by the German physician Adam Haug. Raux, in particular, "enameler in ordinary to the king, Rue aux Juifs," imitated perfectly "the form, the color, and the brilliance" of the natural eye by the aid of various Venetian enamels combined with metals.

It is obvious, therefore, that the technique of the ocularist had made remarkable progress since the day of Ambroise Paré. This art continued to perfect itself with the Anzous, father and son, and above all with the "artist oculist of the king" Charles François Hazard, so that a contemporary could write in 1904: "In the focus of M. Hazard's lamp you will see born the crystalline, the uvea, the iris, the most imperceptible veins. At midday you order from him the eye you lack, and after dinner you go into society with a perfectly matched pair of eyes!"

In spite of the exaggeration of these lines, Hazard, who died at 54 in 1812 was certainly one of the most skilful ocularists of his time. His nephew and pupil, Hazard Mirault, who published the first *Practical Treatise* on the artificial eye in 1818 also acquired a brilliant reputation. Up to this time glass had been used almost exclusively in the manufacture of prothetic eyes; but since this material offered many inconveniences Demmenie, an Amsterdam glass-blower, substituted enamel for it, towards the year 1840; and although since then there have been many attempts to replace it by more resistant plastic substances—celluloid for example—nothing better has yet been found. Even the rubber eyes, advised in 1916 by M. M. Lemaltre and Tevillières, do not seem able to dethrone eyes made of enamel.

Under the action of fire, enamel, or the silicate of potash and lead, takes on, in fact, a remarkable polish which imitates the sheen of the natural eye; the constant friction of the lids does not wear it away too fast; tears can scarcely dissolve it, and it does not irritate the ocular mucous membrane. Moreover, by the addition to this crystal of various metallic oxides we are enabled to imitate the smallest details and the most delicate tints of the sclerotic, the iris, or the pupil.

Until about 1850 Paris practically monopolized the industry. But at that time Ritterich introduced the manufacture of artificial eyes into Germany and Austria, where it became localized at Prague, Saalfeld, and Leipzig. Before the war the ocularists beyond the Rhine competed briskly with our own in the world market and even in France. However, the heterophthalmic nearly always abandon the German specimen because of its defects. In the eye now made in Paris the iris has the same color tone when seen at an angle as when gazed at directly, while in the German eye a layer of white enamel, continuous with the sclerotic completely masks it. Then it nearly always has edges, rough from the grindstone, which irritate the stump, which often remains sensitive after the enucleation, from which headaches may result. Furthermore its enamel is highly charged with lead and becomes sulfurized with use, while at times it even bursts in the socket of the eye because of the dilatation of the air confined between the two shells, provoking in such case an abundant hemorrhage.

To remedy the inconvenience of sharp edges the American Borsch of Philadelphia and the Hollander Snellen devised about 1,900 eyes with double walls which do not wound the bottom of the orbit. A little later, our compatriot, Dr. Coulomb constructed eyes with thick edges which are spreading, presenting in section the form of a tear. Lighter than those with a double shell they can, furthermore, be retouched after being made which helps towards perfect adaptation.

But let us consider the work of a Parisian artist, M. Einius, whom the enamelers of the famous old days would not have refused to accept as a worthy fellow craftsman, and who was kind enough to unveil the arcana of his art to us in a recent visit to his studio.

The principal tool of the modern ocularist is a sort of enameler's lamp. This consists of a small tin reservoir provided with a lid at the top. At the base of this receptacle three small brass tubes are soldered, each about 20 centimeters (8 inches) long, and recurved towards the lamp at their extremety. A cotton wick is placed in each of these burners and the reservior is then filled with gasoline. Then there is placed in front of the burners a branched piece or fork formed by a brass conduit which communicates across the table with a bellows worked by a pedal. Into this tube lead pipes are soldered, curving towards the burners and terminating in other tubes, of brass, to which are attached small glass blow-pipes. Sometimes gas takes the place of the enameler's lamp. The air from the bellows escapes from the recurved fork, which directs it upon the burners. A small box of sheet-iron completely surrounds the latter, protecting the operator from the heat.

The operator works by artificial light and almost in obscurity so as to clearly observe the entire flame of his blowpipe and not mistake one color for another, which would happen if it was fully illuminated by solar light. Working his bellows by his foot he blows the air upon the burners, so that the flame is driven horizontally in front of him. When it becomes blue (an indispensable condition of success, since the white flame is too hot, spotting the enamels and modifying the colorations) he throws its jet upon the part he wishes to heat. He begins with a crystal tube to whose orifice he fuses a tiny drop of enamel of the desired shade. He brings

*From *La Science et La Vie* (Paris).

it to a red heat and then blows it out until it attains the volume of an ordinary marble. We now have the sclerotic roughed out.

Let us state here, in parenthesis, that the oxide of tin provides the opaque white; oxide of cobalt gives indigo blue, and oxide of copper sky blue, while the blood vessels derive their red color from the protoxide of copper. A mixture of the oxide of copper and of iron, with some particles of bichromate of potash, gives green. To obtain yellow tints the artist mixes with his enamel some oxide of silver, oxide of uranium, or more simply, some carbon. The incorporation of oxide of manganese yields violet reflections, and blacks are obtained by adding the oxides of iron, of copper, and of manganese. By varying the proportions of one or another of these substances it becomes possible to copy with truly extraordinary precision the tones of the various parts of the human eye.

The sclerotic in the rough being obtained, the artist perforates its extremity by means of a conical awl. He now leaves this portion for the time being and proceeds to fashion the iris. For this purpose he uses a ring of transparent crystal as a support. Upon this "palette" he paints with his blow pipe the striae of the iris by means of pencils of enamel over whose surface extends a filigree of different tone, while a droplet of black enamel enables him to imitate to perfection any human pupil. He then takes the iris thus made and fuses it to the extremity of the sclerotic previously prepared. The German manufacturers apply the iris directly to the ball without perforating it, thus increasing the thickness of the median portion of the eye. As a result of this the anterior chamber has less depth, but this artifice is one they are compelled to employ by reason of the transparence of their enamels, considerably less opaque than ours.

The workman now cuts off the crystal taking care to leave a droplet large enough to stimulate the relief of the anterior chamber; he then arranges some red threads in the white to represent the blood vessels of the conjunctive. The blowing of the globe of enamel is finished. It must now be separated from the tube which bears it. This is done by means of the flame, the method varying with the operator. M. Einsius proceeds by slashing the edges of the eye with the flame until it is almost detached from its support, then he completes the cutting by means of a tin knife, and grasping it with pincers he places it in the metallic box where it is to be annealed to give it greater strength. Finally it is allowed to cool slowly in the annealing box.

Artificial eyes are excessively fragile to handle in the different phases of their manufacture. The ocularist is obliged to execute each of the above operations without quitting his task, and makes use of skilful tricks of the fingers which it takes a long time to learn. A sudden movement, a stroke too much of the bellows pedal, and the shell may burst or crack. He must also be a clever colorist as well as an expert draftsman to reproduce the tints and slightest details of the living eye which is to be matched, and to make the contour of the edges of the new eye exactly fit the orbitary cavity to be filled.

But of what use is the artificial eye? Without having the importance of a piece of dental prothetic work, which reëstablishes the functions of the organ which it replaces, the ocular prothesis has not only an esthetic purpose, in symmetrizing the physiognomy of a one-eyed man, but, when applied in time it prevents accidents and often causes the functional troubles proceeding from the loss of the eye to disappear.

To fill its rôle perfectly the prothetic device must have certain essential qualities; it must imitate very closely the color, the relief and the curvature of the sound eye; it must be neither too small, in which case it will not fill out the eyelids, nor too large, since it will in the latter case exert pressure on the stump either by its edges or by its posterior surface.

It is obvious that the perfect adaptation of an artificial eye to the patient necessitates many trials and retouchings. The problem is still more complicated when the patient resides at a distance. In this case the oculist chooses from a collection of artificial eyes the one which is most nearly adapted to the needs of his patient and forwards it to the ocularist with instructions as to the modifications required. But the best method of obtaining an eye by correspondence is to take a model of the orbit of the eye with paraffine. Dr. Coulomb has invented for this purpose an ingenious apparatus, which must facilitate the operation.

Some precautions must be observed when introducing the eye into the socket. The operator takes the eye between his thumb and forefinger in the direction of the longest diameter, then places his left hand on the forehead of the patient to lift the eyelid. The patient is then told to look downward and the eye is then slid into place, and held by the thumb. The patient is then directed to look up, while the oculist lets go of the eye with his right hand, then pulls down the lower lid and places the lower edge of the eye in position. To remove the eye a smooth support is used, such as a hair-pin, silver wire with a loop at the end, crochet-hook, etc. The patient looks up and the operator, holding the instrument in his right hand, pulls down the lower lid with a finger of his left hand, and introduces the loop under the edge of the prothetic piece to which he gives a motion from the rear to the front. The eye then passes above the lower lid, and the patient has merely to look at the floor to make it fall out.

By the end of a few weeks the patient will acquire sufficient skill by practice to insert and remove the eye without aid.

In cases where the eyelids have been wholly or are partially removed, the art of the surgeon is required, to make a wax model of the cavity, from which rubber lids are prepared covered with a layer of tinted paraffine, and if necessary held in place by means of spectacles.

Ball Bearings

The remarkable success of the ball bearing is one of the outstanding mysteries of applied mechanics, since the device violates a number of the accepted maxims of the art, in particular the late Professor Sweet's precept that parts liable to wear should be designed so that they cannot wear out of shape, in which case they would not, he maintained, wear much. The extraordinary carrying power and endurance actually realized are a standing tribute to the care in construction and judgment in selection of the materials shown by the manufacturers. Failures, few though they be in comparison with the number of bearings at work, are, of course, not unknown, and these failures formed the subject of a paper recently read before the Birmingham section of the Junior Institution of Engineers by Mr. G. F. Barrett. He observed that while ball bearing makers heard at once of any failure, nothing is said to them when the bearings prove satisfactory, and hence in fixing the loads at which their bearings are rated, makers are commonly much more conservative than users. The load-carrying capacity of the bearings depends on the number and size of the balls. The latter should be as large as possible, but is limited by the thickness necessary for the races. These must be stout enough to be safe from distortion by an outer housing not quite true, and from bursting if forced on to a shaft. The races must, moreover, be sufficiently heavy to be hardened without fear of cracking. These races are, Mr. Barrett states, best made of mild steel, as greater hardness can be obtained by carburizing this than in any other way. A reasonably strong cage is necessary to retain the balls, as, though a light cage suffices if the bearing is merely running under a steady load, it w ll not prevent bunching under shocks and jars. Some makers use a cage only—the ball diameter in thickness, while with others the thickness is one-third the ball diameter. The curvature of the races should be but little less than that of the ball. The excess of the race radius may be as little as five per cent, though with some makers the radius of the race is 20 per cent greater than that of the balls. A ball bearing differs from a plain bearing in the absence of the film of oil, which is capable, under sudden shocks, of acting as a buffer between the opposing surfaces. With ball bearings there is always actual metallic contact, and the stress developed at this point under a shock must be very great. In fact a weight of four ounces falling onto a ball from a height of 10 inches is sufficient to produce a permanent distortion of a half mil. Nevertheless balls of this size are often used in bearings carrying loads of 15 cwt. The carrying power of a ball is commonly considered to vary as the square of its diameter, but Mr. Barrett says that experience shows that in practice large balls carry less than this rule would indicate, and suggests that the working load should be taken as proportional to the seven-fourth power of the diameter. In practice the conditions of use vary greatly, so that actual experience has to be relied upon to show the actual carrying power. Where mounted in light non-rigid housings, as in motor-car work, a lower factor of safety can be used than where ball bearings are used, say, for electric motor spindles. Here the ball race is fitted adjacent to a heavy rotor and in a very rigid cast-iron housing. In fact Mr. Barrett states ball bearings do not stand up at all well in the larger electric machines, and trouble has been met with even with those of more moderate size notwithstanding the adoption of a large factor of safety. For this work roller bearings are much more suitable. In aeroplane work a long life is not expected, and weights must be kept down, so that relatively small bearings are used. A valuable addendum to the paper is a list of suitable sizes of bearings both for light and heavy motor vehicles, based on the practice of the best English makers.—*Engineering.*

Effect of Occluded Air on the Freezing of Pipes

It is a common observation by plumbers that the pipes carrying the hot water from the boiler to the kitchen and bathroom burst from freezing far more frequently than the pipes carrying the cold water. Experiments have been made with glass tubes, the practical conditions being simulated as nearly as possible. The results confirm the above observation, and show that the occluded air in tap water is rseponsible for the delay or absence of bursting of the pipes, says Mr. F. C. Brown in the *Physical Review*. The air and accompanying impurities assist in furnishing nuclei of crystallization so that the ordinary tap water begins to freeze at the usual freezing point. At the same time the ice formed is more mobile, especially near the middle of the tube, so that until very low temperatures are reached the pressure is released along the middle of the tube by the flow of water and ice. In addition the air bubbles displacing water form cushions which also relieve the pressure on the tube to a certain extent.—*The Engineer.*

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Table of Contents

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